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THE PHILIPPINE
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VOL. 1 JANUARY–JUNE, 1951 No. 1

THE PREPARATION AND MANAGEMENT OF BAÑGOS [1] FISHPOND NURSERY IN THE PHILIPPINES [2]

By HERMINIO R. RABANAL, HERACLIO R. MONTALBAN and DOMICIANO K. VILLALUZ
Of the Bureau of Fisheries, Manila

TEN PLATES AND EIGHT TEXT FIGURES

INTRODUCTION

The pond fisheries of the Philippines are concerned primarily with the cultivation of bañgos, or milkfish, *Chanos chanos* (Forskål). At present about 70,000 hectares of bañgos fishponds are scattered throughout the Philippine Archipelago, representing an investment of almost three hundred million pesos. These ponds annually produce approximately 24,500,000 kilograms of fish valued at nearly forty million pesos.

Just when the first fishponds were built in this country cannot be definitely ascertained, but this industry is old, presumed to have been started along the shores of Manila Bay. Although it has not developed along the scientific process of investigation, the industry has attained a high state of development. This has been the result of long years of experience of our fishpond caretakers as evidenced by the fact that certain phases of this fishery have become highly specialized and attained the importance of industries in themselves such as (*a*) the bañgos fry industry; (*b*) the management of the bañgos fishpond nurseries; (*c*) the management of the rearing pond system; and (*d*) the commercial handling of marketable bañgos.

[1] Bañgos is the local name for milkfish, *Chanos chanos* (Forskål).

[2] This paper was presented by the Philippine Delegation before the second meeting of the Indo-Pacific Fisheries Council held at Cronulla, N.S.W., Australia, April 17–28, 1950.

The bangos fishpond nursery as a unit consists of a series of neatly arranged, relatively small, shallow ponds devoted exclusively to the rearing of milkfish fry and fingerlings. In actual practice, fishpond owners or caretakers may manage their nursery ponds exclusively as a unit, or they may operate them as a subunit of a fishpond system devoted to the cultivation of the bangos from the fry stage to the marketable size. Because of the great profit derived, a number of caretakers devote their lifetime to the operation of nursery ponds to grow fingerlings exclusively as a unit. These nurseries, centrally located in Barrio Dampalit, Malaboh, Rizal Province, Luzon, provide a steady supply of fingerlings for extensive areas of rearing ponds but without nursery ponds in Rizal, Bulacan, Pampanga, Bataan, and Cavite Provinces. The nursery as a subunit of a complete system is present in newly developed areas located far from Dampalit, especially in northern Luzon, the Visayas, and Mindanao. In any kind of unit system mentioned above the nursery ponds are operated with special care and management necessary for their maintenance.

SELECTION AND LOCATION OF A NURSERY SITE

Water supply.—A good site for nursery ponds should be accessible to water supply of tidal origin that is adequate throughout the year and free from pollution. Salt water coming directly from the sea may serve, but brackish water from tidal streams is preferable.

Drainage.—It is essential that the nursery pond site is capable of drainage as often as desired, even under ordinary tide conditions. This factor is important, because during certain periods of the year the ponds are drained and dried to eradicate all fish enemies and also to provide ease in working the pond bottom. Such preparations promote the luxuriant growth of the plankton food of fish once water is allowed in the ponds after the drying process.

Soil.—Before nurseries are constructed it is essential that the soil be closely examined to determine whether or not it is favorable. Clay loam, sandy clay, or clay with rich deposits of organic matter is the best soil for the nursery ponds. Hard mud of the above types are preferable to the soft and very loose kind. Sandy, rocky, or stony soil should be avoided as this would not retain water in the ponds and thereby retard the growth of the natural food. Areas with very thick deposits of organic debris are also to be avoided.

Topography.—Level marshes, swamp lands, or tidal flats are the best sites for nursery ponds. If the topography is too undulating, a great deal of leveling has to be done entailing great expense. Besides, excavation work removes the surface layers of the soil which are usually the most fertile portions of the pond bottom. Digging also often inhibits the growth of the natural food.

Vegetation.—Sites that are thickly wooded or forested are too costly to clear and prepare for ponds. Instead, clear areas or those with scanty vegetation should be selected.

Freedom from floods.—Sites that are periodically flooded are to be avoided as the fish under cultivation may be washed away. Flooding and its bad effects can be minimized if dikes are so constructed as not to obstruct the path of rivers. Fishpond caretakers have experienced that areas nearer the sea are safer from the hazards of floods than those further inland.

Availability of bañgos fry and rearing ponds to be stocked.—Nursery pond units devoted to raising bañgos fingerlings need a sufficient supply of bañgos fry from a nearby fishing ground during the year. A good return from one's investment is assured whenever the nurseries are located in the neighborhood of extensive rearing pond areas to be supplied with fingerlings.

LAYOUT AND CONSTRUCTION

Size of ponds.—In the foregoing account the nursery ponds are referred to as relatively smaller in area than the other ponds in the system. The variation in size of nursery ponds ranges from as small as 500 square meters to as big as 5,000 square meters. The ideal ones range from 1,000 to 4,000 square meters. The next series of ponds, the transition, or stunting, ponds, locally called the "impitan," or "bansutan," usually averages 10,000 square meters or one hectare in area. The rearing ponds, locally called "kaluangan," are large ponds for growing bañgos to marketable size. They vary in size from 10,000 to 150,000 square meters, or from 1 to 15 hectares.

Many advantages are derived from the small-sized nursery ponds. Water control which is essential will be effective in these ponds; leveling and cultivation of the pond bottom and the eradication of fish enemies will be easy. Artificial feeding, when resorted to after the natural food in the ponds has been consumed, can be done easily. Likewise, the fingerlings can be confined and caught easily.

Too small ponds or those less than 500 square meters are also disadvantageous, for their maintenance requires too much expense, besides much space which can be made available for the fish is covered by unnecessary dikes. Small ponds also make the fish an easy prey for predators, whereas larger ones provide bigger space for them to escape from their enemies. Furthermore, the smaller ponds lead to an early stunting of the fish in the process of cultivation, whereas the larger ones are conducive to further growth.

Types of layout.—The first type is a model bangos fishpond nursery project for the exclusive cultivation of fry and fingerlings (text fig. 1 and Plate 1, fig. 2). This type consists of the following parts: (1) the nursery pond proper, locally called "pabiayan," or "palakihan," or "semillahan," including its pipes and gates; (2) the catching pond called "kulungan"; (3) a few transition ponds called "impitan", or "bansutan"; and (4) an elaborate system of water supply canals or "sangka." In practice the area adjacent to the tidal stream is devoted to the transition ponds. This arrangement prevents the fry from escaping through leaks on the main dikes and also utilizes these deeper areas to advantage. Late in the season these ponds may also serve as rearing ponds, or "kaluangan," for growing some of the left-over fingerlings to marketable size.

A large and firm main dike is constructed along the tidal stream together with the main water control gates which are often made of concrete. This type of gate is so placed that it opens directly on the path of the water supply canal that extends between the series of nurseries. This canal can supply water to a series of ponds on both sides or only along one side of it.

The size of the nursery ponds of this type usually is uniform. Every two of these ponds are often provided with a common catching pond, or "kulungan" (Plate 5, fig. 1). The catching pond varies in area from 20 to 50 square meters. To prevent the fry and fingerlings from escaping, the nursery ponds are provided with a number of small nursery wooden gates and pipes. Usually only a pipe links the nursery water supply canal with the catching pond. Gates connect the catching pond with the nursery pond proper, but pipes are usually installed near them (Plate 5, fig. 2) to minimize the escape of fry or fingerlings during the early stage of cultivation.

The second type is the commercial nursery pond project (text fig. 2). In this type the area and topography of the site

available must be suitable to the layout of the ponds to be constructed. The ponds adjacent to the tidal stream are usually used as the transition, or stunting, ponds. Sometimes, instead of a water supply canal provided for the nursery ponds, a head pond is used. The head pond is the deepest portion in the system. It serves as a water reservoir and as

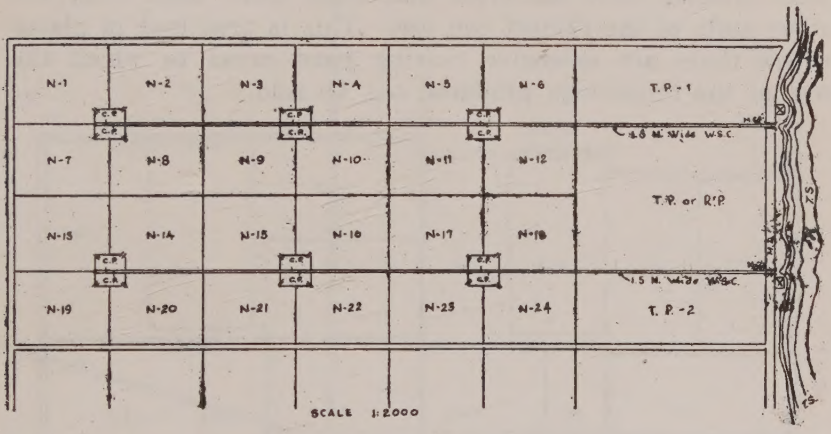

FIG. 1. Model layout of a 6½-hectare Bañgos Nursery Pond System

LEGEND:

N—Nursery pond (*palakihan, pabiayan, semillahan*)
T.P.—Transition or stunting pond (*impitan, bansutan*)
R.P.—Rearing pond (*kaluañgan*)
C.P.—Catching pond (*kuluñgan*)
M.G.—Main gate
M.D.—Main dike
T.S.—Tidal stream
W.S.C.—Water supply canal
—Nursery gate
—Water pipe from W.S.C.
—Caretaker's hut

catching pond for the big bañgos. In this type of layout every two nursery ponds are provided with a catching pond. Nursery gates and pipes are used in similar manner as in the first type described above.

The third type is a combination or a complete self-sustaining bañgos fishpond project (text fig. 3) consisting of three units of ponds, namely, the nurseries, the transition ponds, and the rearing ponds. When such a project is desired the area for

the nurseries might be set aside such that the fingerlings it could supply would be just enough for the whole year required stock of the two other pond units. To do this it is estimated that the size of the nurseries should be 1 per cent; the transition ponds, 9 per cent; and the rearing pond, 90 per cent of the total area of fishpond site. Often many of these complete systems have nurseries that raise more than what the other units of the project can use. This is practiced in places where there are extensive rearing pond areas to which the rest of the fingerlings produced can be sold.

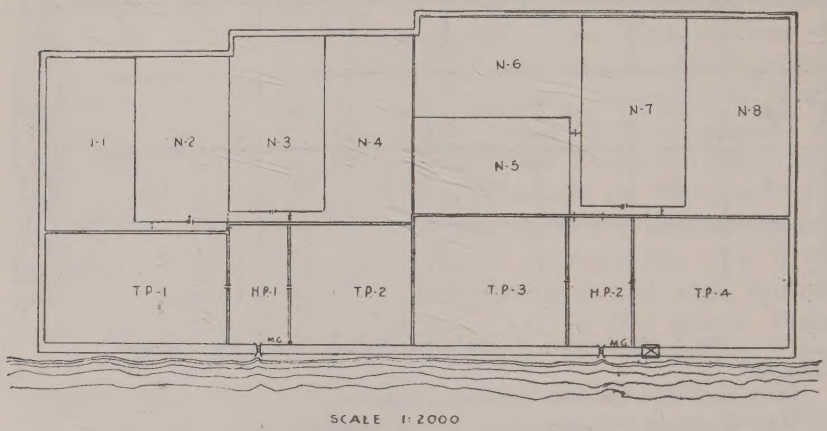

FIG. 2. Commercial fishpond layout for a 5½-hectare Nursery Pond System. H.P.—Head Pond

Dikes.—The main dikes which enclose the project are constructed higher than the highest tide ever experienced in the locality. Typical of fishpond dikes, they consist of a wide base that forms a slope upwards to the top known as the crown. The usual slope of these dikes is about 1.5:1 to 1:1 (base: height). Steeper slopes are subject to erosion while extremely gradual slopes cost a great deal to construct and result in unnecessary waste of space. The main dike along the tidal stream should be the firmest in the system and should be given special care. A generous allowance along the bank of the stream of at least five meters from the base of the main dike should be allotted. This will minimize erosion which is often the cause of undue losses of fish under cultivation.

The secondary dikes form the partition for the different ponds and the system of water supply canals. In a nursery pond project these dikes are smaller than the main dikes and usually steeper in slope. These dikes may have a base

of 2 to 3 meters rising to about one meter in height with a crown of one meter or even a little less. These are well tended and cleaned, and leaks and seepage in them are checked from time to time. They undergo repair at least once a year.

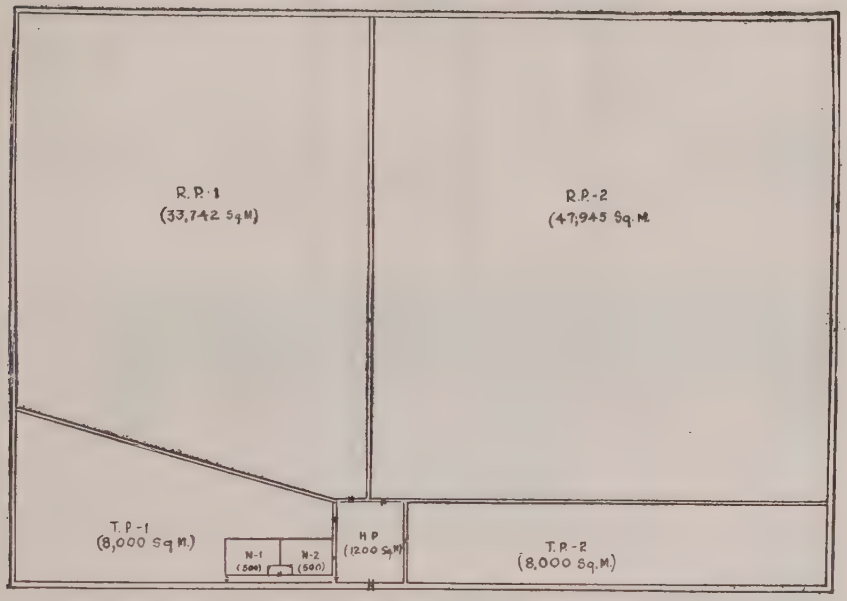

FIG. 3. Model layout of a combination fishpond system showing the relative areas for a 10-hectare project.

Gates and pipes.—The main water control gate is made of concrete or of adobe bricks reënforced with concrete (text fig. 4 and Plate 2). It is located along the main dike, usually in the deepest portion of the pond system. In order to safeguard subsidence of its foundation and future destruction, pilings of bamboo trunks or wood posts are driven in the place where such gate is to be installed. The flooring of the gate is made of stones and concrete and often reenforced with steel bars placed over the pilings. The sides which are about one meter apart rise vertically all the way across the main dike with their outer edges curving outward to form the wings of the gate. This gate is provided with three grooves. A center groove, which is made of first-class wood inlaid into the concrete side of the gate, is used for the wooden sluice gate slabs. The two other grooves, shaped on the concrete sides on both extremities of the gates, are for the screens which are made of bamboo splits attached to a wooden frame.

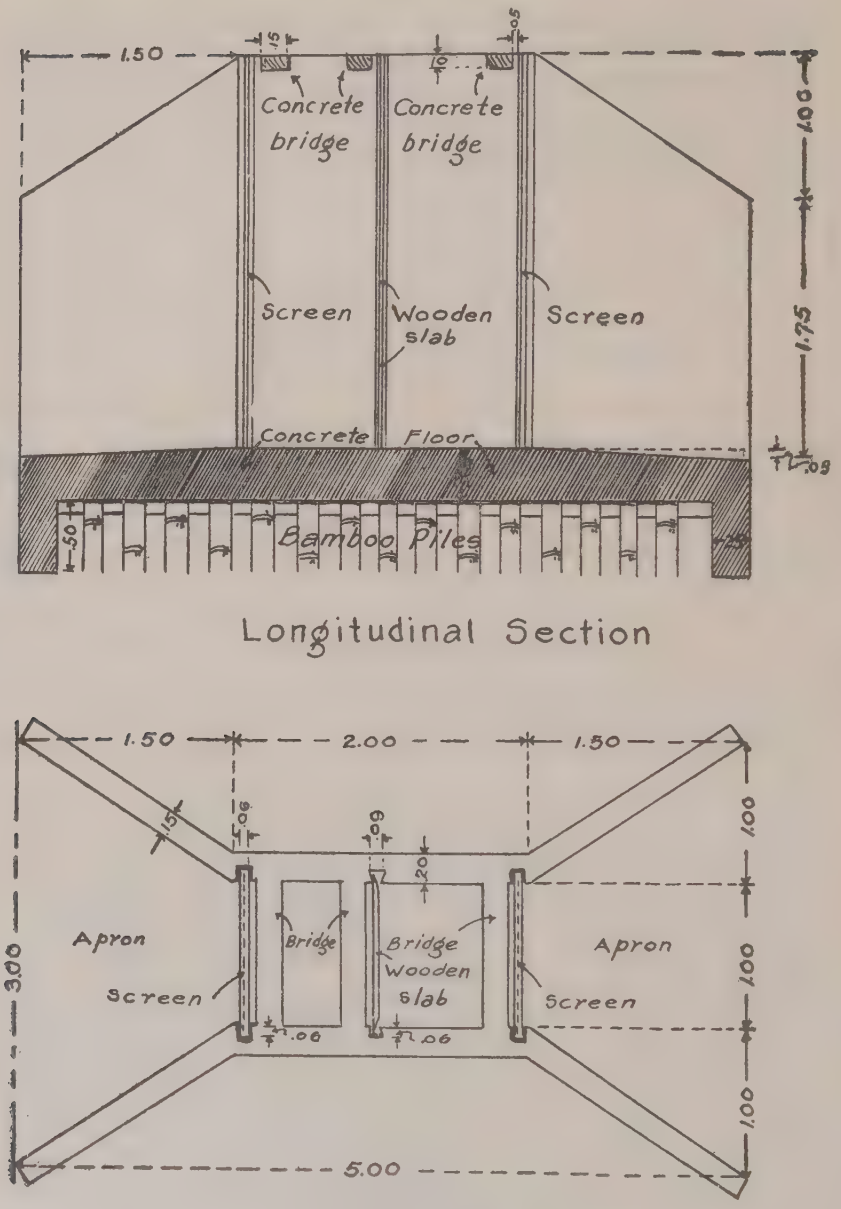

Fig. 4. Details of a main water control gate.

The gates leading to the rearing, transition, and nursery ponds are made of wood (text fig. 5 and Plate 3). These are designated as secondary gates. They are similar in pat-

tern to the main gate except that they are made of wooden pieces nailed together. Three grooves are likewise provided for these gates, a center one for the wooden slabs and two on the edges for the screens.

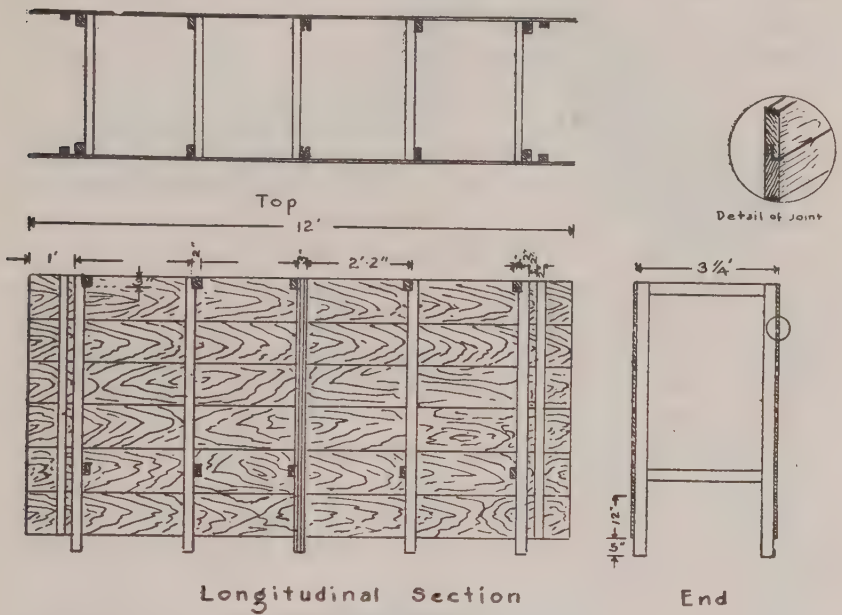

FIG. 5. Details of secondary wooden gate.

Pipes are sparingly used in the nursery ponds because with them the control of the entrance or the exit of fish is better provided. Usually a pipe instead of a gate is used to connect the nursery water supply canal with the nursery catching pond. One or two pipes may also be installed alongside the wooden gate connecting the catching pond with the nursery pond proper.

Pipes used are either quadrangular or cylindrical. Quadrangular pipes (Plate 6, fig. 2), are made by nailing together four pieces of boards. This pipe should be long enough to traverse the base of the dike and protrude about 1/2 meter on both ends. On these exposed ends two grooves are provided near each other. The outer grooves are used for the screens which may be made either of bamboo splits or of fine wire screen attached to a wooden frame. The inner grooves are for the single-piece wood slabs.

Cylindrical pipes are made of wood or of concrete. Those made of wood are trunks of certain palm trees such as the "anahao," *Livistonia* sp. (Plate 10, fig. 2). In making these pipes the trunks of these palms are cut into desired lengths usually varying from 3 to 6 meters. First a hole is bored through the trunk by means of a long-handled drill. Then this hole is enlarged to the desired bore by a gouge which is attached to a long handle. The opening of the pipes varies from 15 to 30 centimeters in diameter and the thickness of the edges left after making the pipe hole usually averages about 3 centimeters. This type of pipe is closed by a solid piece of wooden plug especially made for the purpose. This pipe plug has a cylindrical portion fitting into the pipe to be closed, an enlarged middle portion serving as the knob and an outer flattened structure with a hole bored perpendicularly to the longer axis of the entire piece. Through this hole is inserted a pole or stake stuck to the substratum in order to keep the plug in place when closing the pipe.

Recently concrete cylindrical pipes (Plate 10, fig. 3) have been introduced. These are closed by concrete plugs which fit into the exposed ends of the pipes. While these are more lasting than other kinds of pipes, their weight makes them difficult to install and to handle.

Both of these types of cylindrical pipes are provided with an elongated trap-shaped screen made of bamboo splits, the "galao." When the pipes are to be used their plugs are removed and the "galao" are fitted instead over the protruding ends of the pipes (text fig. 6 and Plate 5, fig. 2).

Provision for better water renewal and circulation.—Proximity to the water supply is essential in a nursery pond project for it provides ease in the renewal and circulation of pond water. This should be considered during the construction of the nursery ponds which should be located as near as possible to the main gate. In instances when the nursery is quite far from the water source a water supply canal is generally constructed leading to the main dike along the tidal stream. This in turn receives new supply of water from the outside by a pipe through the main dike. The use of one catching pond for every two nursery ponds is a good provision for better water circulation. The practice is to put temporary cut through the middle partition dike at its farther extremity so that if water is admitted through one gate and let out

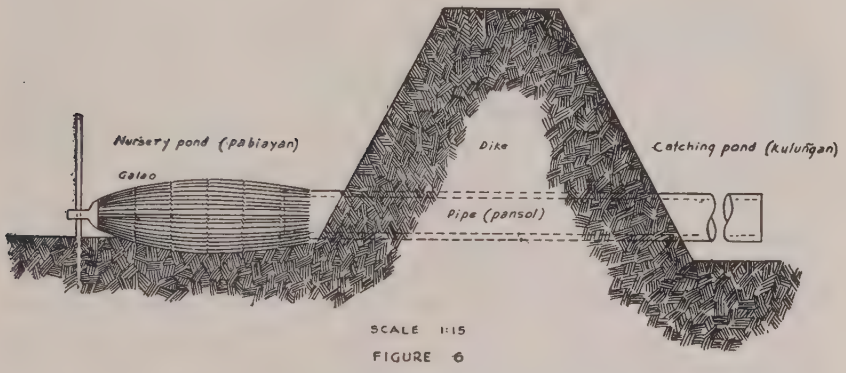

Fig. 6. A cyclindrical pipe with the "galao."

through the other a complete renewal of the pond water is amply provided (text fig. 7).

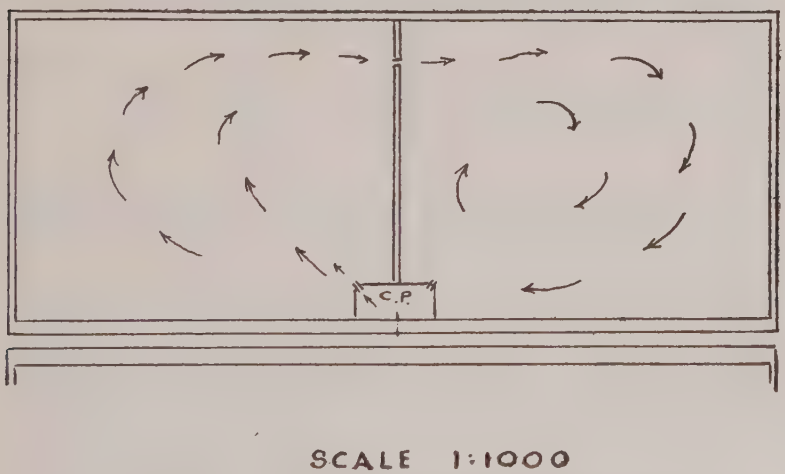

Fig. 7. Provision for effective water circulation in the nursery ponds.

The idea of having a head pond especially if this is deep and large is another provision for insuring a good supply of new tidal water for the ponds. Water stored in the head pond during the spring tides are used to renew the nursery pond water during the neap tides when the water in the stream especially in small and winding creeks is often turbid or contaminated. Sometimes the adjoining transition ponds if devoid of fish are also used as water reservoirs.

PREPARATION OF THE NURSERY PONDS BEFORE STOCKING

Cultivation and leveling of the pond bottom.—Within two months or so, before the arrival of the new supply of bañgos fry for the year, the nursery ponds are cleaned of its old stock of fish. This provides ample time for the preparation of these ponds before stocking. As soon as the caretaker is ready to work on these ponds he drains them during the low tide. The bottom of each pond is immediately worked before it gets dried up and hardened. This is accomplished by stirring or cultivating the pond bottom with a shovel or a rake. By tilling the soil and turning it over the nutrients in the subsurface layers are made available at the surface. The eradication of fish enemies and the destruction of undesirable pond weeds are also achieved during this process.

The cultivation of the substratum makes the mud loose and soft for the leveling that follows. Every season the nursery ponds are meticulously leveled. This is done with the use of especially made wooden rakes (text. fig. 8 and Plate 4, fig. 2)

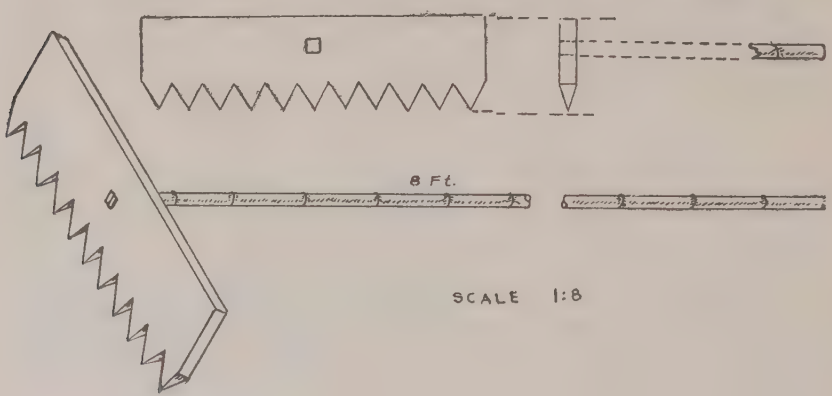

FIG. 8.—A wooden mud rake.

attached to bamboo or wooden pole handles. The purpose of leveling is to make the topography of the pond bottom slope very gradually from its farther extremities down towards the gate which is the deepest portion of the pond. All elevations, holes, and depressions on the pond bottom are leveled off.

Many nursery fishpond caretakers make a canal within the nursery pond that runs from the gate diagonally towards

the opposite corner. Such a canal also slopes and gradually deepens towards the gate. This canal system serves as refuge for the fingerlings during hot days and also renders space for confining of fish when it becomes necessary to catch them prior to their transfer. On the other hand, if the pond is gradually sloping on all sides, oftentimes due to the carelessness of the caretaker, it may become completely dried thus causing wholesale death of fish. Whereas if there is a canal present, this serves as refuge for the fish. One disadvantage, however, of this specially made canal is that many fish enemies live in them which later on do harm to the young bañgos once the nurseries are stocked.

Draining and drying the ponds.—The next step in the preparation of the nurseries is to drain and dry the ponds. Nursery ponds that have been properly leveled and cleaned when drained of its water appear like a well-tended tennis court. The nursery ponds are exposed to dryness for a period of two or three days at the beginning before water is let in. This procedure may be repeated two, three, or more times, to induce the burrowing fish enemies like the mudfish or "dalag," *Ophicephalus striatus,* and certain eels to come up to the surface to die. Later the ponds are finally drained and allowed to dry for a longer period until the bottom soil cracks with dryness (Plate 4, fig. 3).

Thorough drying of the pond bottom has several advantages. The fish enemies and competitors are eradicated completely. Snails and other bottom living organisms which may hinder the luxuriant growth of the natural food of young bañgos are killed. Exposing the pond bottom to dryness may hasten the chemical decomposition of the deposits of organic matter, making them available as nutrients for the growth of the fish food. Soil fertility is, therefore, renewed by this process.

Checking dike leaks and seepage.—Before the beginning of the culture period, that is, before the arrival of the bañgos fry the dikes are cleaned and repaired. All the grasses and other vegetation growing on the fringes of the dikes are cleaned. Eroded portions of the dikes are patched (Plate 4, fig. 1). If there are leaks and excessive seepage through these dikes, complete repair may be necessary. Leaks and seepage can be detected by causing an inequality of the water level within the pond and outside of it. First the ponds are drained at low tide and the gates are then closed. Dur-

ing the next incoming high tide, water is introduced through the main water control gate so that the canals and ponds around the nursery system are flooded with water to slightly below the crown of the nursery dikes. This process could be done the other way, that is the nursery ponds are filled with water as high as possible during high tide. The gates are closed and when low tide sets in, the water outside the nurseries are reduced to the minimum. By means of the two methods described, leakage through the dikes or excessive seepage at certain portions can be easily detected.

The remedy for leaks and excessive seepage of the dikes is to make a puddle trench or "mecha" at the segment of the dikes that are defective. The puddle trench may be an excavation about 30 centimeters wide and 50 centimeters or more deep running along the dike. It may be made at the center of the dike, towards one side, or two puddle trenches dug on both sides of the dike under repair. The puddle trench is long enough to cover the entire seepage area and sufficiently deep that it may go beyond the general level of the pond floor or the adjacent water supply canal. This trench is filled with new mud or soil which should be well settled and not in big blocks of mud in order to give a firm line of earth in this renewed dike. Sometimes if the nursery dikes are badly worn out the entire nursery dikes are repaired throughout their whole length. In this process all holes and leaks are filled with new soil and burrowing organisms such as crabs are caught and eliminated.

Screening and closing the gates and water pipes.—After thorough drying of the ponds, water is let in to allow the growth of the natural food. Utmost precaution is exercised so that the gates and pipes are properly screened and closed with the necessary materials. Screens are of fine bamboo splits and they are further covered with abaca fiber cloth or "sinamay." This is done before stocking the ponds and during the early part of the cultivation period.

The pipes are also properly closed and screened as soon as water is allowed into the ponds. The cylindrical pipes are very effectively screened by the "galao" which fits over the protruding end of the pipe (text fig. 6 and Plate 5, fig. 2). Before stocking the ponds and during the early part of cultivation this "galao" is further coated with abaca fiber cloth. So effective is the screening of these pipes that they are almost exclusively used during the early part of cultivation. The gates which were

diked at the start of the operation are opened later when the fry have grown to the fingerling stage.

Water management in the nursery ponds before stocking.—There are certain important features in the water management of the nursery ponds during the period when the natural fish food is being grown until the fry are ready for stocking. As soon as water is allowed into the nurseries after the drying period, the depth of the water should be maintained to a level just enough to cover the entire floor of the pond bottom or an average depth of from 3 to 5 centimeters. Within three days to a week under this condition the development of the fish food at the bottom floor becomes evident. As the growth of the natural fish food continues to become thick it becomes necessary to provide a corresponding and gradual increase in the average depth of the pond water in order to obtain maximum productivity.

During this period renewal of the pond water with new tidal river water should be done once or twice a week when possible or at least once in two weeks. Renewal of the pond water is made in such a manner that the current of the incoming or outgoing water would not cause too much stirring of the pond bottom. This can be attained by not causing a big range of difference in the water level inside and outside the pond and also by having the gates and pipes properly screened.

A process known as washing the nurseries is undertaken before the fry are stocked. It consists of the renewal of the pond water at repeated and frequent intervals as the tides permit, the purpose of which is to have a complete change of the very saline nursery pond water with new tidal water. High salinity is sometimes indicated by actual crystallization of salt along the shoreline of the ponds. The repeated water renewal washes out this salt and provides new water that is brackish, clear, and well oxygenated which is very essential for the proper growth of bañgos fry.

The growing of lab-lab.—"Lab-lab" is a vernacular term for the brownish, greenish, or yellowish crust of microbenthic fauna and flora of the pond floor. It is the natural food of the fry and fingerlings under cultivation.

Lab-lab is really a "microbenthic biological complex" instead of what it used to be called a "plant complex." The plant components are exemplied by various forms of bacteria, unicellular and filamentous blue-green algae (Myxophyceae)

especially those belonging to the family Oscillatoriaceae, numerous diatoms, and fragments of various filamentous green algae. The animal components of lab-lab which may be as equally important consist of different forms of Protozoa, entomostracan crustaceans like the copepods and ostracods, free-living flatworms, round worms, and larval forms of various kinds of molluscs and larger crustaceans.

It is essential that a luxuriant growth of lab-lab is present in the nurseries before stocking them with fry. All efforts should be exerted to maintain such growth once the fish have been stocked. Lab-lab grows best under the following conditions:

Soil.—The soil must be fertile. Clay, clay loam and sandy clay give better results than sandy or rocky soils. Soils rich with decayed organic matter are also very productive.

Depth of pond water.—Lab-lab grows best when the water is maintained low. At the beginning, water just enough to cover the entire pond bottom should be allowed. For best results, the depth of water is gradually increased as the lab-lab grows thicker up to about 10 to 20 centimeters. The water should not be allowed to go beyond this depth or else filamentous green algae, or "lumut," which is not needed at this stage of cultivation, may develop.

It has been observed that exposure to heat and intense light of the pond bottom filled with shallow water seems to stimulate the growth of lab-lab.

Salinity.—Lab-lab can tolerate big ranges in salinity. Salinities from brackish water conditions to those equivalent to sea water conditions and even little beyond this give good growth (ranges of salinity from 10 to 40 parts per mille). Extremely high salinities, evidenced by actual salt crystallization, cause poor growth of lab-lab. Fresh-water conditions in ponds is found to be definitely detrimental to growth of this fish food.

Water mobility and turbidity.—Stirring of the water due to winds, waves and water currents causes turbidity which is unfavorable for the normal growth and propagation of lab-lab. This can be avoided by planting mangrove trees and other kinds of vegetation around the pond system to serve as wind and wave breaks. Water currents can also be regulated through the gates and pipes.

Freshening the ponds.—Freshening is the process of changing the old, stagnant very saline and stale water in the ponds with clear and well-oxygenated water of lower salinity brought in by the incoming tide. This kind of water favors the good growth of lab-lab so that freshening of ponds should be done as often as practicable. Precaution should, however, be taken that excessive stirring of the pond bottom must be avoided. Water due to rains or that brought in by floods although fresh is usually turbid and should not be used in freshening the nursery ponds.

Presence or absence of browsing organisms which compete with the bañgos fry and fingerlings.—Browsing organisms of various kinds are hindrances to better growth of lab-lab because they feed upon it and

also they stir the bottom causing turbidity and disturbance in the proper growth of this fish food. These organisms include snails mostly of the family Cerithiidae, shrimps, crabs and some species of bottom feeding fishes like mullets and "kitang" (Scatophagidæ) which may have secured entrance into the ponds during their earlier stages of growth. These types of organisms should be eliminated from the nursery ponds as much as possible.

There are instances where there is an overgrowth of lab-lab especially in very fertile ponds. Under this condition some of the lab-lab that float may be gathered and dried. Later on, this can be broadcasted in the ponds as artificial feed of the fingerlings. Overstocking the ponds may help control overgrowth of lab-lab.

Lab-lab has the tendency to float when it has poor growth and also during its later stages of development even if it grows luxuriantly. Floating is further stimulated by excessive heating during the afternoons. This condition is not good because after the ponds are stocked with fish fry most of these jump over floating patches of lab-lab and get entangled in them. To remedy a situation like this the ponds are drained so that the floating patches may again secure foothold on the bottom. Another practice is to break them into pieces by any sort of mechanical device to minimize harm to the fry. Some of these patches if thick and coherent may be gathered and dried for future use.

Some nurseries which are easily reached by fresh water may develop a thick growth of certain aquatic submerged plants collectively known locally as "digman." These plants may comprise of the species of *Ruppia, Halophila, Nejas,* and *Thalassia.* Fishpond caretakers collect these plants and place them in mounds to decay. Fingerlings relish the partly decayed "digman" as food. The growth of these plants in the nurseries should be controlled because they outgrow and overcrowd the lab-lab.

STOCKING THE NURSERY PONDS

The bañgos, as a cultivated species, does not breed under pond conditions. The open sea is its natural habitat and although it has been known to breed almost throughout the year, the height of its spawning occurs in May and June. During spawning season millions of fry are gathered from certain sandy shores and tidal creeks throughout the islands, and these are transported to the fishpond centers.

Upon delivery in the fishponds the fry, which are placed in porous unglazed earthen jars during the transit, are carefully examined. The dead fry are removed and the average number in each container is estimated so that the total number may be computed. Sometimes these fry are sorted before actual stocking into ponds. The procedure consists of the removal of all other kinds of fish fry that may have been caught with them. The fry of predatory species such as those of the Megalopidae, Elopidae, Theraponidae, Gobiidae, and many others are eliminated.

Time and method of stocking.—The best time for stocking the fry is during the colder parts of the day, in the evenings and early mornings. Before the fry are released, it is advisable that the temperature and salinity of the water in the jars and the ponds where they are to be stocked be almost the same. If the difference in these conditions is too great, efforts should be made to have them approximate each other as much as possible, otherwise the stocking may be delayed to avoid undue mortality.

During the stocking the jars of fry are brought to the nurseries preferably near the gates which are supposed to be the deepest parts of the ponds. Each jar is brought down to the pond and tilted toward one side to allow the pond water to flow gently into the jar. This process may be prolonged depending upon the range of difference of conditions of the jar and the pond water. When the jar is almost filled with water it is slowly raised and at the same time further tilted but leaving an air exit at its mouth. In this manner the water with the fry is left in the ponds almost unnoticed and without any agitation. This process is repeated until the desired stock for the pond is filled.

In extensive nursery pond projects the sorting of each jar of fry becomes cumbersome and impracticable. Sorting of the fry in such projects is accomplished during the time the fry are actually being stocked. This is done by making use of a rectangular box of fine screen made of wire or of abaca hemp fiber cloth attached to a wooden frame. This box may measure 30 x 40 x 12 centimeters and open on the top. During the stocking it is immersed in water with the edges exposed so that the fry from each jar could be temporarily retained in this box. An experienced nursery caretaker rapidly goes over the fry being stocked and eliminates any other fry that may have been mixed with the bangos. The fry are released

from this box after each sorting and the process is repeated until the desired number of fry has been stocked. Sometimes instead of the sorting box above described a big porcelain white basin is used. The advantage in its use is that the white background facilitates recognition of the bañgos fry from the young of other species.

The rate of stocking in the nursery ponds.—Stocking rates in the nurseries depend on the amount of food and space available for the fish. One hectare of nursery ponds with good growth of lab-lab may be capable of supporting around 300,000 to 500,000 bañgos fry, or a rate of 30 to 50 fry per square meter. Most nursery ponds are overstocked, but this is advantageous only up to certain limits because in this way the growth of the fingerlings intended as reserve stock for the rearing ponds through the year round is inhibited and controlled. Under this condition the most ideal stock for a given area of nursery pond is the maximum number that it can hold and keep the fish stunted but healthy without causing wholesale death. If the ponds on the other hand are too much understocked, this would require the same amount of care and maintenance but with less income than when the optimum number is stocked. Understocked ponds, therefore, waste space and also result in wide variation in the growth rates of the stock, a condition which is unwanted for species under cultivation.

REARING THE FRY AND FINGERLINGS IN THE NURSERY PONDS

Water management.—After the fry have been stocked close supervision of the nursery ponds is necessary. Proper management of the water may prevent much unnecessary losses at this time. In the first place the level of the water should be maintained low enough (about 10 centimeters on the average) in order to enhance the growth of lab-lab and avoid the possible growth of filamentous green algae which are not needed at this time.

Freshening of the nurseries with water brought in by the incoming tide should be done as often as practicable. The clear tidal water brought in by the spring tides is preferable to the semiturbid and partly contaminated water brought in by neap tides. A daily and almost round-the-clock examination of the pond water should be made so that immediate remedies can be instituted if anything unusual occurs. It is best to keep a reserve of good water in the head pond or in the nearby transition ponds.

During adverse weather conditions, as heavy rains and floods, it is preferable to maintain the pond water high. This would regulate the possibility of sudden change in salinity and temperature caused by rain and freshets which often cause fish mortality.

Constant vigil against dike leaks and seepage should be undertaken. The pond water should never be reduced unwatched as the possibility of drying the entire nursery ponds is very great. Likewise, the screens of the gates and pipes are frequently checked so that any defect can be repaired at once to prevent escape of the stock.

How to detect starvation and diseases in the nursery ponds.—Experienced pond caretakers can easily detect the advent of starvation and other abnormalities of the fish under cultivation. Healthy fingerlings are usually active and they swim in groups. The normal activity is largely confined to active swimming and feeding. Starvation is indicated by the disproportioned body of the fish with the head overly large while the trunk and tail regions appear to be much compressed. It is also under this condition that the fish is more susceptible to diseases. The fingerlings that are starved can further be identified by the appearance of extra shiny luster at the bases of the fins. This may be caused by slight protrusion of the supporting bones of these regions. Starved or sick fish also show weakness in motion. One very good criterion is the appearance of some specimens that exhibit deep hue of blackish color on their backs. These may swim singly and not in groups and also they may not be so receptive to an effort to scare them. Some caretakers believe this to be a condition of blindness.

Managing overstocked ponds.—During the earlier stages of cultivation the intensity of cultivation may far exceed 30 to 50 fry per square meter without harm to the stock. As the fish grow, however, overstocking becomes evident and unless remedies are made wholesale death of fingerlings may result. The usual practice under this circumstance is to reserve the adjacent nursery for the distribution of fish contained in the overstocked area by simply making a break through the partition dike and allowing the stock to spread. If after the food in the two adjacent nurseries are consumed and they are still overstocked, some of the larger fingerlings can be transferred to the transition ponds, or they can be disposed off to other fishpond owners. Partial thinning of the stock is accomplished in this manner.

Artificial feeding.—As the fish stock in the nurseries continues to grow, the ponds may no longer be able to replenish the growth of natural food. The fish can be maintained stunted in these ponds but they should be healthy in order to keep them from diseases and death. This can be accomplished by artificial feeding. If available, dried "lumut" or filamentous green algae can be used.

Very fine rice bran, or "darak," has been found to be the cheapest and most easily available artificial feed for the fingerlings. This is applied by broadcasting darak to the ponds twice a day once in the morning and another in the afternoon (Plate 7, fig. 1). The amount of rice bran to be given depends on the number of fish in each pond. One hectare of nursery ponds with a stock of about 300,000 fingerlings will need about 5 to 12 kilograms of rice bran per day. Fingerlings after the first few days of feeding easily learn to feed on the rice bran. They learn to nibble continuously on the bran particles on the water surface. Later they even learn their regular feeding times and the place in the ponds where they are fed. In this way the nursery pond projects are able to maintain the continuous stock of stunted fingerlings for the large rearing pond areas throughout the year or at least until a new stock of fry becomes available.

CAUSES OF MORTALITY IN THE NURSERY PONDS

Mortality due to unfavorable conditions of the environment.—Overstocking is a very common mistake in nursery fishpond systems. It has been commonly observed in the overstock ponds that wholesale death of fish occurs in the early mornings. This may be due to oxygen deficiency in the water caused by the excessive use of oxygen by pond organisms during the night and the lack of a compensating supply of oxygen due to photosynthesis.

Lack of food resulting in starvation may not be a direct cause of mortality but if this condition persists, the fish become weak, stunted, and susceptible to diseases. The fish may remain stunted but their health must be maintained by supplying the necessary nutrients for body sustenance.

Pollution of the pond water is another very common cause of wholesale death of pond fishes. This may be caused by excessive decomposition of organic matter in the pond or by polluted water brought in by the water supply. Supplying the ponds with artificial feed much in excess of what the fish can utilize often results in their death due to pollution.

Part of the mortality of pond fishes may be ascribed to extreme changes in water characters such as temperature, salinity, turbidity, and excessive precipitation often accompanied by floods. These unfavorable conditions may be remedied by maintaining a large supply of residual water in the pond to minimize the effect of sudden changes of these environmental factors.

Predators, parasites, and diseases.—The animals that prey upon bañgos fry and fingerlings include fishes, amphibians, snakes and other reptiles, and birds. The predatory species of fish that are commonly encountered in the nursery ponds include the following:

1. Elopidæ. *Elops hawiiensis,* the ten pounder, "bid-bid."
2. Megalopidæ. *Megalops cyprinoides,* the tarpon, "buan-buan."
3. Ophicephalidæ. *Ophicephalus striatus,* the murrel or mudfish, "dalag."
4. Theraponidæ. *Therapon* spp., the grunts, "bagaong" and "ayungin."
5. Anabantidæ. *Anabas testudineus,* the climbing perch, "liwalo" or "martiniko."
6. Latidæ. *Lates calcarifer,* the sea bass, "apahap."
7. Serranidæ. *Ephinephilus* spp., the groupers, "lapu-lapu" or "loba."
8. Carangidae. *Caranx* spp., the cavallas and crevalles, "talakitok," "pampano," "muslo," and "salay-salay."
9. Lutjanidæ. *Lutjanus* spp., the snappers, "also" and "maya-maya."
10. Gobiidæ, Eleotridae, and Periophthalmidae, the gobies, "bia" and "talimusak."
11. Synbranchidae, Anguillidae, Muraenesocidae and Muraenidae. The eels, "palos" and "igat."
12. Ariidæ. *Arius* spp., the sea catfishes, "kandule."

These fish predators gain access into the ponds either with the bañgos fry or through the gates with the incoming water especially during their larval stages. The fry of ten pounders and tarpons are strikingly similar to bañgos fry that it is very hard to sort them out during stocking. The murrels and the climbing perch occur only in nurseries where the water is fresh. The above carnivorous species, when present in the nursery ponds with the bañgos, grow very rapidly and within a short period cause a tremendous reduction in the stock of fish. During the early stages of cultivation these predators may confine themselves around the vicinity of the nursery gate. To reduce their number, the caretaker usually repeatedly dips a fine-meshed scoop net near the gate screens to catch some of the predators lurking around. Sometimes their presence could be detected by a scramble of bañgos fingerlings trying to keep clear of the path of these predatory species.

The amphibian predator is the common frog, *Rana vittigera,* a member of the family Ranidæ. It usually lays its eggs along the edges of the nursery pond before the fry are stocked. These hatch and develop and when the fry are stocked, the parents as well as the young frogs prey upon them. In order to get rid of frogs their eggs should be removed and they should be hunted out at night by using lights especially in newly stocked ponds.

Predatory snakes in bañgos nurseries include *Disteira ornata* and *Lapemis* sp., or "kalabukab," and *Chersydrus granulatus,* or "malabasahan." These are very pugnacious feeders on the bañgos fingerlings and all means should be made to eradicate them. They are usually hunted out with lights. To minimize their presence and to provide ease in killing them the nursery dikes should be cleaned of all sorts of vegetation and debris which may serve as hiding places for these snakes.

Nurseries further inland where the water supply is fresher are occasionally visited by predatory lizard, *Varanus* sp., of the family Varanidæ. This should be closely watched as it is a big and voracious predator and may cause disaster to the fish stock.

Bird predators are very rampant in nursery pond areas. These include the kingfishers, *Alcedo athis bengalensis* and *Halcyon chloris collaris,* or "kasay-kasay"; the common tern, *Sterna hirundo longipennis,* or "kalangay"; the purple heron, *Ardea purpurea manillensis,* or "kandang-ahô"; the eagles, *Butastur indicus,* or "lawin"; the bittern, *Butiroides striatus carcinophilus* and *Ixobrychus* spp., or "bakaw"; and the cattle egret, *Bubulcus ibis coromandus,* or "tagak." These birds may come singly or in big flocks and cause considerable losses to the nursery stock if control measures are not provided for. Nursery caretakers are usually provided with shotguns to kill these birds. There are also varied types of contraptions devised. Scarecrows and noise scares are often installed amidst the ponds. Another innovation is to place bamboo poles at regular intervals along the fishpond dikes. To these poles lines of cotton twine are tied so that the ponds are traversed by these lines of strings. The birds which usually have the habit of diving for their prey are scared by these lines.

Parasite infestation on bañgos fry and fingerlings in the nurseries is rare and the possibility of death due to this cause may be remote. External infestation of flat-worm and crustacean parasites has been reported.

The diseases of bañgos fingerlings have not been well studied. An epidemic disease due to fin rot has been recorded but this is of rare occurrence. Whether this was caused by diet deficiencies or by fungous parasites was not ascertained but strict disinfection and isolation of the case involved was recommended and the recurrence of the disease has not been reported.

Pests, nuisances, competitors and other causes.—There are certain periods when bulblike egg cases of some marine annelids develop in great numbers in the ponds. These are made of a transparent jelly or mucilaginous mass attached by a stalklike anchorage on the pond bottom. The tiny eggs of an annelid belonging to Eunicidæ are lodged in these masses. The active swimming fry and young fingerlings often swim into them and get entagled thus causing their death.

The development of the filamentous algæ in the nurseries is a nuisance because the fry and young fingerlings cannot yet utilize them for food. It is not uncommon that some of these fingerlings get wrapped up in the algæ filaments and die.

Higher aquatic plants that occasionally invade the pond bottom are also a nuisance. Their growth lessens the space for the fish and prevents the growth of the natural food. They are often gathered and placed in mounds to decay so that they can be made available as food for the young bañgos.

Crustaceans which may have come with the bañgos fry or entered through the gates are enemies of the bañgos especially during the earlier stages of the cultivation. These include representatives of the shrimps and crabs. It has been observed that the larval *Penaeus* spp. often cause death of the fry when their sharp rostrum pierces the delicate fry. In later stages of cultivation the stirring caused by these crabs and shrimps on the pond bottom causes turbidity which is not favorable for the growth of fish and the food of fish under cultivation.

There are several types of small and prolific fishes which may secure entrance into the nurseries and are in one way or another unfavorable for pond-fish cultivation. These types include representatives of the Ambassidæ, Poecillidæ Phallostethidæ, Hemiramphidæ, and Leiognathidæ. These fishes either utilize the same food on which the fingerlings feed or compete with them for space.

Some fishes of similar food habits as the bañgos may also grow in the nurseries and in many instances give additional income to the fishpond owners. These, however, are competitors for the food and space and should be eliminated from the

nursery ponds. Species of the families Scatophagidæ, Mugilidæ, Siganidæ, and Dorosomidæ are among the most common examples under this group.

The accidental drying of the nursery ponds sometimes causes wholesale death of bañgos fingerlings. This may be due to very porous soil, poor pond construction, or negligence of the caretaker. The nursery pond is dependent on the tide for its water supply. Proper water management often demands round-the-clock supervision. Only long experience and fine technique will reduce possible mortality due to these causes.

A great number of fingerlings are often lost because of rough handling. This is common especially when fishes are to be transferred from pond to pond or during the transportation to the rearing ponds. Giving the fish enough space and the proper kind of water is essential. Handling should be minimized to avoid removal of scales and mutilation of the fins, two very common causes of the susceptibility to diseases.

COMMERCIAL HANDLING AND MANAGEMENT OF BAÑGOS FINGERLINGS

The rate of growth of the bañgos fry and fingerlings in nursery ponds is quite rapid. The small transparent and almost needlelike fry measure from 1.0 to 1.5 centimeters long and weigh from 0.002 to 0.006 gram when stocked in the nursery ponds. With enough food they grow very rapidly during the first four to six weeks when the fry attain fingerling size, or "hatirin" stage. This stage of growth can be maintained in the nursery ponds for several weeks or even months with only slight increase in length and weight. The fingerlings vary in size from 5.0 to 10.0 centimeters in length and 1.2 to 5.0 grams in weight. It is at this stage that the young bañgos may be transferred to the transition ponds, then to the rearing ponds of the same fishpond project, or they may be disposed of to owners of extensive rearing pond areas. In the transition ponds the rate of stocking per unit area is less and the fish feed for the first time principally on filamentous green algæ, or "lumut." While in these ponds, the young bañgos grow very fast and hardy enough to withstand conditions obtaining in rearing ponds where they are grown to marketable size.

The ability to keep the fish stunted without causing mortality in the nursery ponds is utilized to advantage in the storage of a continuous fish stock. Stunting the fish in the nurseries is accomplished by overstocking the ponds and at the same time supplying them enough food. In this way the sizes of the fish

are maintained and they remain as uniform as possible. As stated previously extremely overstocked ponds are not good because these result in the recurrence of wholesale death of fish. On the other hand, understocked ponds produce large variation in the sizes which are not the right stock for planting in the ponds. By proper technique nursery caretakers are able to maintain their stock for a year or even longer in order to supply the wide areas of rearing ponds during the entire year even if bangos fry come only during a single season.

Confinement and catching of fingerlings.—The minimum period of time for the rearing of the fry to fingerlings in the nursery ponds is from 1½ to 2 months. From this time on, the fingerlings may be disposed of to rearing pond owners for stocking their transition and rearing ponds. To do this the fingerlings are first confined (Plate 7, fig. 2) after which they are caught and counted before actual transfer is made.

Fingerlings are confined in two ways. The first method utilizes the tendency of the fish of swimming against the current while the second method is by making the fish go with the current.

To accomplish the confinement of fingerlings by allowing them to go against the current, the nursery pond concerned is first partially emptied of its water during the preceding low tides to keep the fingerlings in a small space and expose them to intense heat during the day. During the next incoming high tide, new tidal water is allowed in and a gentle flow directed to the nursery pond. The fingerlings will struggle to swim towards the new water passing through the gate up to the catching pond where they congregate. After a sufficient number have been confined, the nursery gate is closed.

To confine the fish by making them go with the current, the nursery pond is drained until most of the pond floor is exposed leaving water only in the canals and in the catching pond where the fish congregate. As soon as the desired number has been confined, the nursery gate is closed and water from some source previously reserved is then allowed to flow into the ponds to avoid mortality of the confined fish. This method is usually used when catching of the entire stock is desired. The first method is often used when only a part of the stock is needed.

The fingerlings thus confined in either case are thereafter caught. The catching is done with a fine-meshed seine called "panagap," especially made for the purpose (Plate 8, fig. 1). From this net the fingerlings are placed in pails and transferred

to a suspension net or "bitinan" (Plate 8, figs. 2 and 4). The bitinan is a fine-meshed rectangular net of variable size depending on the capacity desired. It is set by tying the corners firmly to four bamboo poles stuck to the bottom. By doing this, the middle portion is immersed while the edges are left above the water. The suspension net is usually set in a pond with sufficient amount of water, or along the water supply canal.

Counting the fingerlings.—The fingerlings caught from the nursery catching pond are placed in the bitinan for convenience in counting (Plate 8, fig. 3). In counting the fingerlings a very unique method has been evolved. First a bamboo pole is taken and placed horizontally at one end under the suspension net. This pole is raised and gradually worked toward the opposite end so as to drive the fingerlings to about ⅓ or ¼ of the entire net surface. Another pole is placed horizontally and at right angles with the pole first placed in such a manner that the entire number of fingerlings is about equally divided into two parts. By this time, these operations are being done by representatives of both the dealer and the buyer. The foreman on the dealer's side usually does the dividing while the foreman on the buyer's side feels and tries to determine which part contains more fingerlings. The part selected is discarded to the other side of the net. Then the dealer's side again divides as before the part that was not selected and the buyer's side makes the selection as before. This process is repeated until a convenient number is left to be counted out. In the operation the dealer always attempts to make the division as equal as possible while the buyer attempts to have the least number counted out so that when summed up the number actually counted will be less than the actual composition of the stock. Counting is accomplished by scooping with a bowl or cup a few fingerlings from the portion to be counted. As this is done the number is called out and recorded by one who tallies with the use of shells or pebbles of known quantity that are placed in a tray. The number of times these tally shells or pebbles went around and any fraction thereof represents the number in the counted portion. To get the total of the fingerlings in the entire batch this number is multiplied by 2 if the stock is halved: by 4 if ¼ is counted; by 8 if ⅛ is counted; by 16 if 1/16 is counted and by 32 if 1/32 is counted. The purpose of reducing the amount of fingerlings to be counted to a convenient number is to effect speed in counting and to minimize handling of the fingerlings.

Transportation of live fish.—Bangos fingerlings are distributed from the nursery pond centers to the various rearing pond areas by means of live-fish boats locally called "pamandawan," or "hatiran" (Plate 9, fig. 1). A hatiran may be a wooden-dugout or a flat-bottomed wooden boat. A wooden dugout ordinarily measures from 10 to 20 meters long propelled by an outboard motor. The bottom of this boat is provided with two or more well-screened holes for the free entrance of the water. A flat-bottomed bargelike boat is usually a larger vessel with much greater capacity than the former. Depending upon the size, each of these live-fish boats may carry from 15,000 to 50,000 fingerlings. If more fish is to be transported, two or more of these carrier boats are usually towed by another powered vessel (Plate 10, fig. 1).

The live-fish boats are thoroughly cleaned a day before they are to be used. The pipes for the water holes are checked and properly screened. As soon as these boats are about to be used for fish transportation they are filled with about ⅓ to ⅕ full with river water. After the fingerlings have been counted in the suspension net, they are scooped by means of pails and transferred to the live-fish boats (Plate 9, figs. 2 and 3).

The fingerlings can be transported even under crowded condition in these live-fish boats. It is essential, however, that water circulation and aeration be maintained. This is done by opening the water holes as soon as the fingerlings are placed in the boats. These boats are prevented from sinking by bailing out the incoming water. This is continuously done by one or more of the personnel of the boat during transit. To avoid having the fingerlings dipped out during the process, water is bailed out from a especially made enclosure with the bottom made of boards and the walls of bamboo screens. The meshes of the screens are fine enough to exclude the fingerlings.

There are certain precautions that should be taken into consideration during the transportation of fish. First of all, fingerlings should not be transported during inclement weather such as typhoons and floods. Turbid waters and shallow areas where the boats may run aground should be avoided. The entrance of mud and other sources of turbidity may cause fish mortality. High tide is the best time for transporting and it is preferable if transport can be accomplished during the colder parts of the day, from late afternoon through the night to the early morning. Maintenance of water circulation should be done continuously

during the trip by constant checking of the water entrance and bailing out of the water (Plate 9, fig. 4).

The holes through the bottom of the live-fish boats are often provided with a short tube made of bamboo. This tube is cut flat and screened at the inner end but the exposed end is transversely cut. This is done so that if it is desired to vary the rate of flow of water into the live-fish boat this tube could be manipulated. If the hole of such tube is adjusted to face the direction of the boat, more inward flow of water is effected. If this opening is sidewise, the water is slightly regulated, but if turned backwards the inward flow of water would be least. Because of the function of this tube it has been named the "panasa" literally meaning, regulator, of the flow of the water.

Upon arrival in the rearing pond areas, the fingerlings are again scooped by means of pails and transferred to a transition pond, or "impitan," which has previously been prepared. This pond can be stocked with 1 to 15 fingerlings per square meter. It should have newly freshened water and abundant food. In many instances, it may have a very luxuriant growth of filamentous algæ in which case the caretaker should attempt to make pathways for the swimming space and grazing areas of the fingerlings.

SUMMARY

1. The cultivation of bañgos, or milkfish, is a very lucrative and highly developed industry in the Philippines. One of the specialized phases of this industry which involve experience and technique is the preparation and management of the bañgos fishpond nursery.

2. In the selection of the nursery site, the following factors should be taken into consideration: clean and adequate water supply, proper drainage, fertile and clayey soil, more or less flat country, freedom from floods, absence of very thick vegetation, and availability of bañgos fry and rearing ponds to be supplied.

3. The layout of the nurseries is characterized by regularity in arrangement and relative smallness and shallowness of the ponds. The construction should provide for good water circulation and freedom from leaks and seepage.

4. The preparation before stocking consists in the cultivation and leveling of the pond bottom followed by drainage and thorough drying. Then with the gates and pipes properly screened,

a limited amount of water is allowed into the ponds for the growth of "lab-lab," the natural food of the fry and fingerlings under cultivation.

5. The bañgos fry are sorted and carefully stocked into the ponds during the colder hours of the day. The stocking rate is about 30 to 50 fry per square meter of nursery pond.

6. Close supervision is necessary during the rearing of the fry and fingerlings. When the natural food gets exhausted, the fingerlings are artificially fed with fine rice bran.

7. The causes of mortality include unfavorable conditions of the environment, predators and diseases, various pests and nuisances, and competitors.

8. The rate of growth of the fish is very rapid during the first few weeks but later the growth becomes stunted. This condition could be maintained for a considerable period thus making these nurseries serve as storage for reserve stock of fingerlings. The maintenance of the stock and its distribution are handled under the usual commercial procedure.

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ILLUSTRATIONS

PLATE 1

FIG. 1. General view of a bangos fishpond project.
2. The nursery fishpond system showing typical arrangement of ponds.

PLATE 2

FIG. 1. The main water control gate. This is made of concrete.
2. Close view of the main water control gate. Note slabs, screens and bridges.

PLATE 3

FIG. 1. Digging the site for a secondary wooden gate.
2. A newly set secondary wooden gate. Note screens and slabs.

PLATE 4

FIG. 1. Preparation of the nursery ponds begins with repairs of the nursery dikes.
2. The nursery ponds are cultivated and leveled by rakes.
3. View showing a nursery pond drained and exposed until the bottom cracks with dryness.

PLATE 5

FIG. 1. Two nursery ponds have a common catching pond.
2. A nursery gate with a cylindrical pipe alongside it. Note the pipe is screened by a bamboo screen trap, the "galao."

PLATE 6

FIG. 1. One end of the quandrangular pipe partly exposed showing screen and slab.
2. Close view showing details of a catching pond.

PLATE 7

FIG. 1. When the natural food in the nurseries are exhausted the fingerlings are artificially fed with rice bran.
2. Fingerlings are confined in the catching pond so they could be caught and transferred.

PLATE 8

FIG. 1. The confined fingerlings are caught by a fine-meshed seine, the "panagap."
2. Men ready to transfer the fingerlings. Pails are used to scope the fish.
3. Estimation of the fingerlings and actual counting are done while in the suspension net.
4. The caught fingerlings are transferred to the suspension net, the "bitinan."

PLATE 9

FIG. 1. A group of live-fish boats, the "pamandawan" at anchor.
2. From the suspension net the fingerlings are transferred to the live-fish boats.
3. Pails are used to transfer the fish from the suspension net to the live-fish boats which had previously been partially filled with water.
4. Water circulation and aeration in live-fish boats are maintained by constant entrance of water through holes at the bottom of the boats and by constant bailing out of the water.

PLATE 10

FIG. 1. The live-fish boats are towed by a small-powered vessel during transportation.
2. Making cylindrical wooden pipes for nursery ponds.
3. Concrete cylindrical pipes for nursery ponds.

TEXT FIGURES

FIG. 1. Model layout for a 6½ hectares bangos nursery pond system.
2. Commercial fishpond layout for a 5½ hectares nursery pond system.
3. Model layout for a combination fishpond system showing the relative areas of the ponds for a 10-hectare project.
4. Details of a main water control gate.
5. Details of a secondary wooden gate.
6. A cylindrical pipe with the "galao."
7. Provision for effective water circulation in the nursery ponds.
8. A wooden mud rake.

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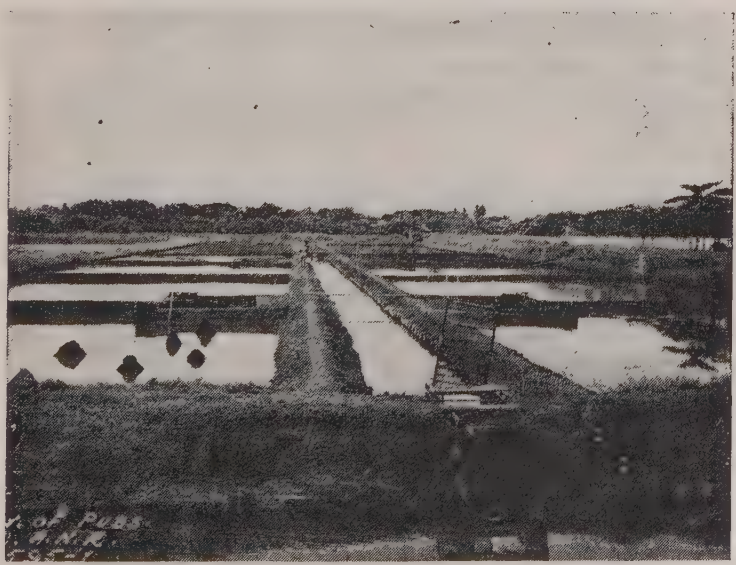

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PLATE 1.

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PLATE 2.

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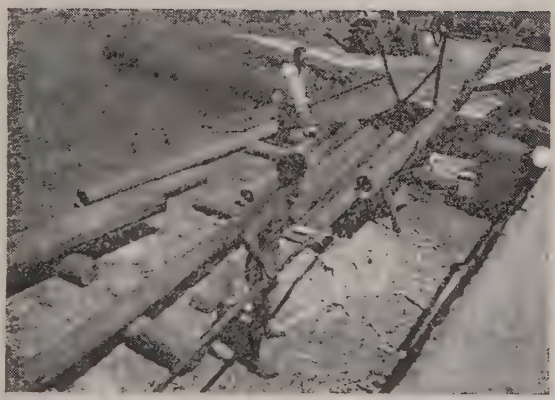

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PLATE 10.

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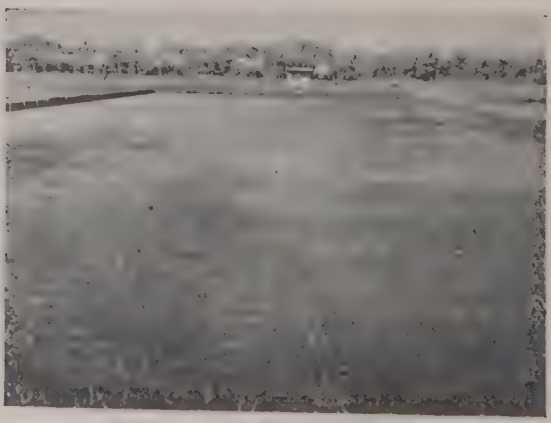

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PLATE 4.

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PLATE 5.

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PLATE 6.

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PLATE 7.

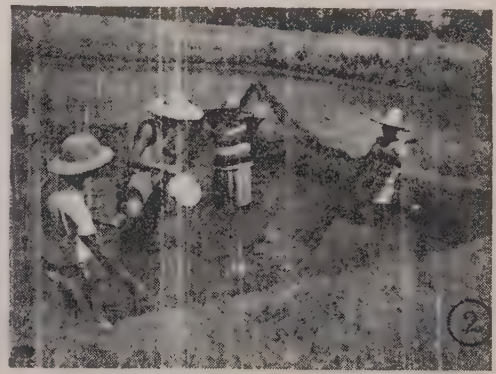

PLATE 8.

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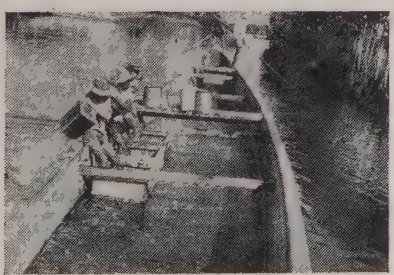

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PLATE 9.

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THE CULTIVATION AND BIOLOGY OF OYSTERS AT BACOOR BAY, LUZON[1]

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FIVE PLATES

INTRODUCTION

The cultivation of the oyster is not at all a new venture to increase one of man's shellfish foods, for it started in China some 2,000 years ago. The early Romans also cultivated oysters. Today, oyster culture is at its peak of development in France, Holland, Norway, United States, Japan, Canada, England, and Australia. In the Philippines the culture of this important shellfish is just in its initial stage of development.

Within Bacoor Bay, Cavite Province, Luzon, alone there are about 200 hectares of oyster farms belonging to private individuals who have adopted the artificial cultivation of four species of oysters—*Ostrea iredalei* (talabang chinelas), *O. malabonensis* (kukong kabayo), *O. cucullata* (pulid-pulid), and *O. palmipes* (culot) by the stick (tulus), the hanging (bitin), the line (sampayan) and the tray (bangsal) methods. The rapid development of the oyster culture industry in this bay is due to the desire of local fishermen to have other sources of income aside from actual fishing and other home industries. There are many private oyster growers who have utilized every space of their enclosed areas so as to increase the production of oyster to the maximum. Bacoor Bay is ideal for the culture of oyster owing to the availability of heavy spats every year in the month of August and of materials for making oyster cultch and to the abundance of its natural food. In the government oyster experimental station at Binakayan, Kawit, Cavite, oysters are

[1] Presented by the Philippine Delegation before the Second Meeting of the Indo-Pacific Fisheries Council held at Cronulla, N.S.W., Australia, April 17–28, 1950. Submitted for publication June 5, 1950.

grown from one to two years and are harvested before the height of the breeding season which occurs in May, June, July and August.

The Binakayan Oyster Farm of the Bureau of Fisheries was established in May 1935 by Messrs. Heraclio R. Montalban and Florencio Talavera. The purpose of the project was to help the oyster farmers of Bacoor Bay develop their oyster industry along the scientific methods of oyster cultivation. A small area in Bacoor Bay was obtained by permission from the municipal council of Kawit through the help of Mr. Julio Handog, an oyster farmer of Binakayan.

A local method of raising oysters by planting bamboo brushes and bamboo trunks, or "puno," for catching oyster spats has been an early practice by a few oyster farmers of Bacoor Bay. Recently it is supplemented by the introduction of the hanging and the improved tulus methods.

Any study along the proper utilization and conservation of fishery resources is the work of the State and not the concern of the individual. Fishermen are extended help and receive benefits from the results of investigations conducted at the fishery experimental station along the field of fishpond culture, oyster cultivation, fish capture, or fish processing. The rapid development of our fishery resources is the result of the application of modern and up-to-date technique and methods in fisheries biology and technology gained in the experimental stations of the Bureau of Fisheries.

Since liberation, the Binakayan Oyster Farm has been rehabilitated with an initial investment of 15,000 pesos.[2] Its area was increased from one-fourth to one hectare. The farm has a station building 30 by 20 ft. of floor space, built with cresoted post, bamboo, and nipa. At the time of the rehabilitation of the station, the cost of labor and material was four to five times higher than that before the war so that the initial capital of fifteen thousand pesos allotted for the station could not go very far. A drawback to the work was the scarcity of building materials. Iron wires were not available at the start and bamboo butts or trunks were used instead, employing the stick or tulus method of oyster cultivation.

The station serves as a demonstration and stock farm. In this station, oysters are allowed to grow from one to two years in order to produce quality oysters for breeding and stocking

[2] One peso equals 50 cents United States currency.

purposes. It supplies the Philippine Fishery Program of the U. S. Fish and Wildlife Service with oysters for canning and bacteriological analysis. It also serves as a training ground for students of the Philippine Institute of Fisheries Technology, Bureau of Fisheries, in fish culture and fish preservation.

DISCUSSION AND METHODS

The stick (tulus) method (Plate 1, A).—It was proven years before that one of the methods tried with success at Binakayan was the tulus method in which dried bamboo trunks, puno, were used. They were cut into pieces 4 feet long and then split into 4, 5, 6, 7, or 8 pieces, the number depending upon the diameter of the puno. For each tulus were impaled 4 old oyster valves. The cultch are usually stored and then planted before the spatting season in July since spatting of oysters takes place from August to the early part of September of every year at Bacoor Bay.

Between July to September 1946, there were planted in the area adjacent to the station 22 plots of 28,000 tulus. A plot consisted of three rows of tulus, about 240 ft. long and 2.5 ft. wide, and the tulus were 5.7 inches apart. Plots Nos. 1 to 11, about 80 meters long, were laid out in August 1946; and plots Nos. 12 to 22 in the later part of September and early part of October 1946. Plots Nos. 17 to 22 were planted with tulus without the impaled shells.

The intensity of spatting on the different plots was observed and results recorded. Plots Nos. 1 to 11 which were planted with tulus in the later part of July and August of 1946 were heavy with oyster spats forming an average of 79 oysters spats to the shell. Then the barnacles came in later and set sparsely on the shell of the oyster.

The whole puno posts of the fence enclosing the one-hectare farm together with the bamboo slats attached to the posts were thickly covered with oysters.

Plots Nos. 17 to 22 planted with tulus without the impaled shells were stocked in the later part of September and early part of October 1946, hence oyster spats were not expected to attach heavily as the time was not within the period of heavy setting of oysters. During the succeeding spatting season of oyster in 1947, plots Nos. 17 to 22 were improved as there had been additional oyster spats on the oysters previously attached, although they were not so heavy. It has been proven that the life of a tulus submerged in water is from two to

three years as the bamboo (cultch) is not free from the molluskan as well as the crustacean borers. The sea water with silt and sticky mud hastens the deterioration of the tulus. With the added weight of the clusters of oysters that had grown for two years on the cultch, the upper part of tulus becomes heavy with mature oysters, causing them to fall to the bottom.

The hanging (bitin) method (Plate 1, C).—This method shows the manner in which the plots Nos. 1–14 are arranged. Each plot is 100 meters long and one meter wide. It is formed by three rows of bamboo butt posts about four feet apart. On the parallel series of posts are whole bamboo stems nailed horizontally at bout 2.5 ft. from the muddy bottom and supported with short puno halves, each one meter long, nailed at the posts across the three rows of parallel bamboos.

The cultch or seedling collectors are about 2.5 ft. long, from Nos. 8, 9, 10, 11 and 12 G. I. wires (Plate 5). To each cultch are threaded 5 old oyster shell valves and 4 small "usiw bung-bong" tubes, *Schizostachym toppingii* Gamble, 5–6 inches long in between the threaded shells. The cultch of threaded shells are prepared in the month of June and July and stored ready for attachment in August in the constructed plots that were also built in June or July. The cultch were attached to staples fastened 5 inches apart to the parallel bamboo of each of the plots.

There are 14 plots for the hanging method of oyster growing. Plots Nos. 1 to 4 were constructed on June 15–30, 1947; plots Nos. 5 to 10 on July 1–31, 1947; and plots Nos. 11 to 14 on August 1–15, 1947. The attachment of the cultch was also gradual in the plots constructed in June, the attachment occurring in July; in the plots constructed in July, the cultch were attached in August; and in those plots built in the early part of August, the cultch were attached in the later part of the same month.

The intensity of spatting in the hanging, or bitin, methods for all the plots, Nos. 1–14, was not uniform. In the seed collectors hanged in plots Nos. 1–14 in July, the oyster spats were abundant but later covered sparsely with barnacle shells. The posts in plots Nos. 1–14 and the parallel bamboos nailed to them were covered thickly with young oysters three months after they were built. In the cultch hanged in plots Nos. 5 to 10 in August, oyster spats were also abundant but fewer

barnacle shells were growing on the young oysters three months after.

The line (*sampayan*) *method* (*Plate 2*).—A plot 120 meters long by a meter wide was constructed about the later part of August 1947 when the intensity of oyster spatting was at its ebb. It consists of several series of inverted V-shaped pairs of full length bamboo puno frames which are 4 meters apart. Each frame has across each base short No. 10 wire tied about 2½ feet from the bottom. The cultch for the line (sampayan) consists of a long line of threaded old oyster shell valves spaced by usiw tubes 5–6 inches long. The line cultch, 120 meters long, are six in number and are parallel to each other at a space of six inches and are each tied from one end to the other end of the plot. Other line (sampayan) cultch were placed along the fence in three layers at the posts of the fence in between the bamboo railings. The oysters in the line (sampayan) devices were not very thick and hence the growth after 10 months was better and larger in size, as there was no over crowding.

The tray method (*Plate 1, D*).—At the oyster farm there are placed in a portion of the area between the plots of bitin and tulus four rectangular bamboo trays each about four meters long and one meter wide. They have split bamboo floor and partitions. Each tray has four compartments and is elevated and supported with bamboo posts. Oyster seedlings, when about six months old, are removed from the string of oyster cultch and then placed in each of the compartments of the trays. Culling the oysters is an important practice to separate the marketable oysters from the undersized. The accumulation of mud and debris on the tray prevented the oysters from feeding readily, hence did not fatten as expected.

Three screen trays of three meters in length and one meter in width, provided with wire screen covers, were hanged on bamboo poles supported with puno posts. The fallen oysters were recovered and placed in these trays for a period of from three to four months where they improved.

To remedy the entire loss of oysters, farmers every now and then gather the fallen oysters and place them in the elevated bamboo rectangular trays or in the rectangular wire screen trays. This saves the fallen oysters from suffocation. If let alone at the mercy of sedimentation of sticky mud, the fallen oysters would eventually die. Gathering fallen oysters and placing them in said trays facilitate oysters harvest.

Other methods of oyster cultivation unsuccessfully tried at the experimental farm in 1938 consisted of the use of wire bags filled with oyster, scallop, and clam shells; twigs and branches of trees; bamboo and wooden screens; shells threaded on rope (kabo-negro), *Arenga pinnata* (Wurmb.) Merr. hung from frames of floats; shells threaded on round rattan of ¼" in diameter hung from fences and floats; kabo-negro and abaca wound about frames and lowered in the spawning area; and other materials.

FOOD VALUE OF OYSTERS

Oyster meat either fresh or preserved is in great demand. It is prepared and served as oyster stew, oyster chowder, oyster omelet, oyster cocktail, salted oyster or "ginamos." It plays a significant rôle in one's diet for it is a rich source of iron, copper and iodine containing one-half as much as calcium, three times as much as magnesium and much more phosphorus than an equal quantity of milk. It is comparable to liver and milk in its rich sources of nutrients as well as Vitamin A, thiamine, riboflavin and ascorbic acid (Newcombe, 1944).

MARKETING OF OYSTERS

Oysters grown in suitable areas are marketable when they are six months old, they are better suited for the market in their first or second year under Philippine climatic conditions. Oyster harvest occasionally takes place in December, January, February, March, and April. The best time for harvesting them is during June and July, when they are fat. There are times when oysters eight to twelve months old are offered for sale in the markets of Cavite City, Kawit, Binakayan and Bacoor. Usually a basket (kaeng) of oysters sells at 4 pesos. Shucked oysters are oftentimes offered for sale.

One way of solving the marketing of this perishable product is the preservation of oyster meat by canning, smoking, and salting it into bagoong. As there is overproduction of oysters at Bacoor Bay almost every year, one should look into the possibilities of growing seed oysters for transplantation in other suitable areas in the Philippines. The American slogan for the conservation of oysters is "Harvest the Crop, and Keep the Seed." This holds true in Bacoor Bay where there is always an abundance of seed oysters. The replenishment every year can keep up with the demand in the markets and the possibility of canning oysters or making bagoong for exportation has a bright future for this young industry.

Oyster shells can be manufactured into poultry grit and lime for construction and other industrial purposes. They can be sold for oyster cultch as well as for road-building purposes.

SYSTEMATIC POSITION OF OYSTERS OF THE GENUS OSTREA LINNAEUS

Twenty-three species of oysters of the genus *Ostrea* have been reported or described in the Philippines. This number is being reduced to twelve due to synonymy, misplacement to proper genus, and status of fossil species. The oysters that are of doubtful existence in the Philippines are *Ostrea mytiloides* Lamarck, *O. orientalis* Jay, *O. paulucciac* Crosse, *O. isognomon* Linnæus and *O. malleus* Linnæus.

Dillwyn (1817) stated that *O. mytiloides* Lamarck reported from Zamboanga, Mindanao, was a fossil species. That *O. orientalis* Jay was synonymous to *O. bilineata* Rolding (1798) which is *O. (crassostrea) gigas,* according to Thunberg, and *O. iredalei* of Faustino. According to Reeves' Conchologia Iconica, *O. orientalis* Chemnitz is a species not properly identified. Faustino (1932) redescribed *O. orientalis* Jay as *O. iredalei* on account of the improper identity of *O. orientalis* by Chemnitz.

The species *O. isognomon* Linnæus and *O. malleus* Linnæus are species not of the genus *Ostrea* of the family Ostredæ but species of the genus *Isognomon* Solander (1886), *Malleus* Lamarck (1799), of the family Isognomonidæ Kuroda (1940).

The genus *Ostrea* of the family Ostredæ is being represented in the Philippines by the following: *O. affinis* Sowerby; *O. cucullata* Born; *O. cumingiana* Dunker; *O. denticulata* Born; *O. echinata* Quoy et Gaimard; *O. glomerata* Gould; *O. hyotis* Linnæus; *O. imbricata* Lamarck; *O. iredalei* Faustino; *O. lugubris* Sowerby; *O. malabonensis* Faustino; and *O. palmipes* Sowerby.

Superfamily OSTREACEA

Family OSTREDAE

Genus OSTREA Linnæus, 1758

Shell of two unequal valves unimascular, foliaceous; hinge toothless with linear margin; ligament, partly external and lamiscated upon trigonal area in each valve.

The species of oysters under this genus have a wide range of geopraphical distribution and are found inhabiting seacoasts and deep seas in the tropic, temperate, artic and antartic zones. Their form depends largely upon the mode and object of attachment, making it difficult to distinguish the different species (Smith 1878).

Shell transversely oblong, solid, rough, purplish in color, with undulated margin and large acutely angular plicae. Inside golden brownish with margin broadly purple. Cicatrix large, ash in color, posteriorly lateral. Hinge nearly terminal in front, small and trigonal.

OSTREA CUCULLATA Born. The wild oyster.

Shell subtrigonal, solid, plaited, whitish toward apex, purple toward margin, lower valve extending deeply beyond flat opercular upper valve. Interior yellowish brown with slight purple tinge. Upper valve brownish near base, purple toward margin, denticulated to about two-thirds from hinge line.

Habitat.—Numerous places in the Philippines.

OSTREA CUMINGUIANA Dunker. The milky oyster.

Shell radiately plicate, transversely subovate, solid, milk-white, tinged with rose and fawn, bluish underneath; inside painted chestnut, greenish gold, blue margins. Muscular impressions deep chestnut. Lateral margins denticulated towards umboes. Ribs of upper valve rounded, rather depressed. Lower valve slightly angular, deep wrinkled over-reaching upper valve at margin.

Habitat.—Philippines.

OSTREA DENTICULATA Born. The denticulated oyster.

Shell subround, thick, glabrous, slightly margaritaceous. Lower valve, large, flattened, widely foliaceous with greenish-white borders. Upper valve convex, obscurely tuberculated. Hinge flattened, golden brown. Internal margin strongly denticulated. Inside part of shell brownish purple, iridescent.

Habitat.—Samar.

OSTREA ECHINATA Quoy et Gaimard. The echinated oyster.

Shell compressed, thin, accuminated towards hinge, roundish beneath. Lower valve sometimes deeply concave; upper valve armed with tube-shaped purple outstanding spines.

The species occurs attached to rocks just below high tide mark on both coasts of the Pacific Ocean and Japan Sea.

Habitat.—Philippines.

OSTREA GLOMERATA Gould. The conglomerated oyster.

Shell thick, irregular, sharp ribbed, with margin dentated, wrinkled or lobed. Upper valve opercular, compressed with thick concentric laminae. Lower valve cucullated, purple. Hinge generally attenuated, produced, pointed. Differs from *O. cucullata* Born. in having numerous strong ribs. Inside edge purple or black. Lateral margin denticulated.

Habitat.—Bacoor Bay, Cavite Province.

OSTREA HYOTIS Linnæus. The hyotoid oysters.

Shell irregularly subquadrate, solid, armed with tube-shaped spines standing out upon angles of about seven large folds. Color greenish brown. Auricles rather compressed, plicated, widely bordered with brown inside.

Habitat.—Daet, Camarines Norte, Luzon; Zamboanga and Basilan, Mindanao.

OSTREA IMBRICATA (Lamarck). The imbricated oyster.

Shell foliaceous, thin, radiately plicated, pink, ornamented with large purple irregular spots of pale fawn tinted with reddish brown; middle folds large, bifurcated, angularly rounded with imbricated tubes at angles. Lower valve very often foliaceous.

Habitat.—Cebu.

OSTREA IREDALEI Faustino. The slipper-shaped oyster.

Shells variable in shape depending on the mode of attachment. Those growing in bunches elongate, sometimes tongue-shaped. Other subtrigonal, sometimes oblong. Very foliaceous, with prominent beak, lower or left valve excavated generally with purple tint. Upper valve smaller, thinner, flatter, generally yellowish brown, sometimes with faint radiating rays of purple, covered with thin laminae, scaly at margins.

Hinge toothless, valve margins inside smooth. Shells interior chalky white. Muscle scar purple, located near center.

Habitat.—In many parts of the Philippines.

OSTREA LUGUBRIS Sowerby. The lugubrius oyster.

Shell thin, obliquely subtrigonal, slightly auriculated, greyish purple, obscurely rayed, rather smooth, shining whitish within. Anterior side produced at ventral margin. Upper valve flattened, subopercular. Lower valve convex, obscurely ribbed, expanded at margin beyond upper valve. Muscular impression reniform, nearly black.

Habitat.—Philippines.

OSTREA MALABONENSIS Faustino. The horse-nail-shaped oyster.

Shell subtrigonal or irregularly oblong, generally not found in bunches but attached singly to other objects of shells. Lower valve concave, deep, plaited with large, rounded numerous plaits. Upper valve plain or partly plain at middle, plaited at margin. Interior of shell with greenish brown spots, margins toothed.

Habitat.—In many places of the Philippines.

OSTREA PALMIPES Sowerby. The palm-rooted oyster.

Shell much compressed subquadrate, thin very inequivalve, inequilateral, fulvoid, rayed with purple or black. Anterior side very short, sloped. Dorsal margin straight while ventral margin rounded, lobed. Umboes small, accuminated. Upper valve small, smooth. Lower valve more expanded, radiately striated, ribbed, tuberculated, produced at margin, flattened interstices.

The peculiar characteristic of this pretty oyster is in the outer surface of the lower valve, which from the radiating ribs ending in lobes and the flattened surfaces between, presents the appearance of the webbed food of a bird.

Habitat.—Philippines.

LIFE HISTORY OF THE OYSTER

Species of the genus *Ostrea* may be either a male or a female. It may usually start as a male and then change into a female or vice versa in its first, second, or third year depending upon favorable environment factors as observed by biologists in the sex behavior of *Ostrea virginica*. In one spawning season as many as half a billion eggs may be liberated into the water by a single female and more so of sperms by the male oyster. The high rate of mortality of larval oysters is due to its "planktonic" state. They are being utilized as food by fish, sandworms, sea-squirts and mussels and other aquatic animals. Climatic factors like wind and tide may strand them on the shore. In tropical as well as temperate countries sudden change of temperature kills the larvae. Industrial wastes discharged into the water poison the young oysters.

Another type of oyster reproduction in temperate countries is the "incubatory larviparous type" where there is a regular and frequent alternation of sexual phases.

Out of the half billion eggs spawned by each female only a few hundred survive to settle as "spats" and with the subsequent loss of spats and growing oysters, on the average only two from each spawning mother come to maturity under natural conditions (Thompson 1946). The high mortality of the larval oysters is compensated by the great fecundity of this mollusk.

In Philippine waters oysters spawn in May, June, July and August at a water temperature ranging from 18°C. to 20°C. There is nothing new in the embryological development of the oyster as it has been well worked out. Oyster eggs and sperms

unite shortly after spawning to form the fertilized eggs. Each fertilized egg undergoes cleavage and umbo stages with cilia for locomotion in its early "plankton" larval embryonic life. After about twenty-four to thirty hours a "straight line" hinge larva about 1/400 of an inch in length is formed. This stage possesses the minute shell which later develops into an "umbo" larval stage after three or four days. It differs from the preceding stage in size and shape. After eight to ten days the "umbo larva" which is also planktonic becomes attached to a suitable rough object or a "cultch" and as such it is referred to as "spat."

FEEDING OYSTERS

The larval oyster is equipped with organs of locomotion and digestion, hence in its planktonic stage it feeds upon nannoplanktonic material which is abundant in the oceanic zone. The availability of such food is a critical factor for the survival of the larvae which are abundant in the oceanic zone and estuarine systems, the best spatting grounds.

Studies on oyster's nutrition (MacGinitie 1937) revealed that the cilia on the gill apparatus in many animals have been credited the selective function of obtaining food and is actually performed by mucous sheets through which the water is strained, and that the cilia on the gill apparatus furnish the mechanical power for creating current. Further investigation on the Lamellibranch molluscs including the oysters emphasizes the fact that a sheet of mucus entirely covers the gill during active feeding and it is this mucus which strains out food from the water. The cilia only creates the current and moves the mucus by which the food-laden mucus is transported to the mouth (MacGinitie 1941).

The adult oyster obtains food by straining water through its gills and retaining food particles which are later directed toward the mouth. The gills of the oysters are very important part in feeding in addition to their respiratory and excretory functions.

The natural foods of the adult oysters vary as to locality and the season of the year. However, phytoplankton such as Dinoflagellates especially *peridinium,* diatoms (*Navicula, Nitzschia, Rhizosolonia*), and zooplankton as *Protozoa* and copepod larvae compose the food of oysters.

In estuaries of low salinity, oysters feed mostly on flagellates and in small bays or coves of high salinity, they feed on diatoms.

Other feeds found in the oyster stomach consisted of larvae of bivalve shells, barnacles, and bryozoans.

The availability of food depends also upon the manner of cultivation of the oyster. For instance oysters cultivated by the "hanging method" in deeper portions of the bay have more chances of obtaining planktonic food as they are not crowded in clusters and under this condition they sway and feed readily.

This brings us to the point of the difference of abundance of planktonic food in an estuarine environment and that in an open bay or cove. During the dry season, in small bays or coves, where oysters are grown, there is always a deficiency of available food owing to physical and chemical changes such as high temperature and salinity of the water, etc., so that in March, April, and May oysters are clean and watery. The absence of admixture of fresh water obtain in bays and coves during dry weather affects the abundance of planktonic foods for the oysters; for instance, planktonic organisms are few.

In an estuarine environment, biotic factors present are entirely different from those in a bay or cove. There is the mixing of fresh and salt-water components and the consequent accumulation of salt material, the proportion of salt and fresh water varying from season to season and from locality to locality and, therefore, there is a very wide range of salinity and other properties which constitute a favorable environment. Hence, there are always available planktonic foods streaming in and out of the estuary for the oysters.

Problems concerning the food and feeding of oysters are numerous and remain still unsolved regardless of the intensive studies of the physiology of oysters. Biologists do not agree on the effects of different quantities of materials suspended in water upon the efficiency of the feeding of oysters. Some maintain that oysters and other mollusks are able to feed only when the water is comparatively clear while others believe that they can feed even in the presence of turbid water.

Experiments on the feeding of (*Ostrea virginica*) with *Chlorella* sp., *Nitzschia closterium*, *Euglena viridis*, and other species (Loosenoff and Engle 1937) have shown that there were definite concentrations above which the density of the microorganisms begins to interfere with the feeding of oysters. The above authorities had worked on the concentrations corresponding to approximately 2,000,000 *Chlorella*, 70 *Nitzschia* and 3,000 *Euglena* to 1 centimeter of water. It was found that much higher number of small cells like *Chlorella* was

needed to produce the same effect as that of much smaller number of larger organisms; that in concentrations higher than those given above, the feeding slowed down and the shell movement changed noticeably. When plankton were given abundantly, little or no feed was taken in by the oysters. They eject large quantities of feces to cleanse their gills and palps of the excessive plankton. Their shells sometimes remained opened for several hours without inhaling water. When oysters were subjected to heavy concentrations of food for long periods of time they become sluggish.

The oysters in light concentrations, which contained fewer cells than those mentioned above, exhibit normal rate of feeding and shell movements. The rate of feeding in many instances was fast when the oysters were kept in running sea water. It was observed that the presence of small quantities of plankton in sea water stimulates the pumping activities of the oysters. Oysters were found to feed in water containing relatively large number of microorganisms although the feeding activity is very much produced. When the plankton was too heavy the oysters stopped feeding.

INTENSITY OF SETTING OF OYSTER SPATS

In June of 1948 there were prepared at the Binakayan Oyster Farm 600 strings of seed oyster collectors ready for the August oyster spatting season. Oysters locally called "talabang chinelas" "kukong kabayo"and "pulid-pulid" spawn at Bacoor Bay intensely in August when biotic factors as salinity, temperatures, and conditions of water are favorable. The collectors were set around the fence above the sampayan of oysters in August 1948 to catch the spats. Samples of five strings of cultch were examined daily for the presence of spats up to the end of the month. There was an average of 875 spats to a string of cultch of 35 oyster shells.

The vertical distribution of oyster spats in Bacoor Bay was worked out by Villaluz (1938). It was found that the average number of spats per string collector at sitio Binakayan was 96 out of 16 string collectors of 1,544 spats. In Noveleta, 4 string collectors were found with 291 spats or an average of 72 spats; at sitio Dalahican 7 string collectors had 139 spats or an average of 34 to the cultch. At Bacoor Bay, spats are available at a depth of from 42 to 112 centimeters from the surface of the water, so that the greatest intensity of setting is obtained at 84 centimeters from the surface of the water.

At constant temperature of 23.3°C. the optimum range of salinity for development of the larvae of *O. gigas* was from 22.2 to 27.5 parts per thousand (Kusakabe, 1926). At about 25°C. the optimum salinity for the development of the larvae is about 20 to 26 parts per thousand with the minimum at about 8 parts per thousand and the maximum about 26 per thousand (Amemiya, 1928). At lower temperature the oyster larva would develop into greater range at 15°C. the optimum salinity was between 17 and 26 parts per thousand, with a minimum and maximum, respectively, at about 6 and 37 parts per thousand.

The pacific oyster (*O. gigas*) in Japan begins to spawn when the water temperature reaches 15°C. (Fujita, 1928). The spawning of the Pacific oyster takes place from the middle of May to late in June when the temperature of the water is around 25°C. (Amemiya, 1928). Galtsoff (1930) was able to make female oyster in aquarium to spawn at 30°C. and when stimulated by sperms at 25°C. Females normally spawn in tanks at 24°C. and when stimulated with sperms suspension they spawn at 20°C. (Elsey, 1933). Pacific female oysters were observed to spawn in the laboratory by Schaefer (1938) at temperature ranging at 17.4°C., 16.4°C., and 21.5°C. Hopkins (1936) observed a female Pacific oyster to spawn at 8°C.

TRANSPLANTATION OF SEED OYSTERS

On October 7, 1948, two hundred strings of seeds oysters from Binakayan Oyster Farm were shipped to Iwahig Penal Farm, through the request of the Director of Prisons. The shipment of the said seed oysters, the sizes of which were 1 millimeter to one centimeter, took 78 hours, which means that they were out of their natural habitat that length of time before reaching their destination at the oyster farm project in Palawan. The transplanting of the seed oyster from Bacoor Bay to Palawan was a success as there was only 25 per cent mortality according to the report of the Bureau of Prisons.

With the numerous private oyster farmers at Bacoor Bay, one branch of the oyster industry that could be properly developed is the growing of seed oysters in August for transplantation in other suitable known oyster areas in the Philippines. The encouragement of oyster farming to help alleviate the shortage of quality protein food demands a thoughtful consideration on the part of our fishing population. As it is now, oyster is still a "richman's dish." It is available only to a small portion of

our population. As a food delicacy no other seafood surpasses oyster when it comes to its food value.

ESSENTIAL FACTORS FOR THE CULTIVATION OF OYSTERS

1. For the broadcasting method of oyster cultivation, hard non-shifting bottoms must be available where clean salt water with adequate food organisms circulates over the oyster bed. In the case of oyster beds of sticky blue mud, where nature is being helped to cultivate oysters artificially, usually small sheltered bays, or coves, or estuaries are selected.

2. Oyster breeding stocks must be present in sufficient quantity to supply the seed oysters.

3. Availability of adequate cheap materials for cultch [bamboos, puno, oyster shells, etc.] to offer clean, firm surface at the time the oyster larvae are ready to set.

4. Culling oyster for purposes of growing them faster and fatter should be an important general practice.

5. Harvesting should be done at the proper time when the oysters are in good sizes for marketing.

6. Oyster beds or areas must by all means be free from predators, enemies, and other competing organisms.

FACTORS AFFECTING PRODUCTION OF OYSTERS AT BACOOR BAY

During the year 1947 the Binakayan Oyster Farm did not escape the ravages of four successive typhoons. The plot for the oyster seedlings was partly damaged when about 20 per cent of the bitin seedlings fell off the bottom as they were detached from the staples due to the wave action. About 30 per cent of 28,000 stakes fell to the bottom. This was due to the condition of the tulus of bamboo trunks that had been eaten up by borers. The line, or sampayan, cultch that were placed at the puno and bamboo fence also gave way and even the fences around the area were also destroyed.

The most significant cause of mortality of the oysters in October, 1947 was the flood of oil from sunken oil drums and oil barges from the Navy Yard at Sangley Point, Bacoor Bay, during the typhoon "Jean." The oil pollution in the bay lasted for five days. The quality of six-month-old oyster that survived was affected by the flood of oil, and the harvesting of the oyster was suspended for a considerably long time.

During adverse conditions like drought when water temperature is high, oysters in shallow coves, bays, and estuaries die.

In cases of water above or below the optimum salinity oysters are affected by the absence of food suspended in water.

The common cause of the falling off of oysters is the attack of borers on portions of the stakes. If fallen oysters are not recovered within a few days from date they fall off, the majority of them dying due to suffocation as they become covered with silt and mud.

From time to time oyster valves are seen opened with the meat content entirely absent both in the bitin and in the tulus, while others are just beginning to open and some are freshly dead. The death of these oysters is caused by natural enemies like the starfish, oyster drill, and internal parasites like the polychaet worm, polydora, and annelids. The luxuriant growth of sponges and seaweeds on oyster beds also accounts for the suffocation of oysters in their natural habitat.

Another cause of low production of oysters is the loss of oysters due to silting or sedimentation in time of floods when oysters grown by the spreading methods are partly or wholly covered by sediments, mud, sand, and other debris.

SUMMARY

The artificial cultivation of oysters in Bacoor Bay is still in an experimental stage. Every conceivable oyster-culture practices here and abroad has been tried at the Binakayan Oyster Farm Station to popularize oyster farming in the Philippines. The utilization of our shallow seas, coves, bays, and estuaries to produce more food, for the growing population of our country is indeed a serious undertaking that necessitates moral as well as financial support. The Bureau of Fisheries shoulders the responsibility of planning a program of shellfish conservation for the State by educating our fishermen along modern methods of oyster farming through demonstration oyster farms built in strategic places throughout the Philippines.

As a food delicacy oyster meat is important in one's diet for it contains proportionate amount of calcium, phosphorus, iron, iodine, copper, Vitamin A, thiamine, riboflavin, and ascorbic acid. No other seafood surpasses it. It is as good as liver and milk for food.

One way of solving the marketing of this perishable product is by canning, smoking and salting oyster meat. The oyster shell is important for cultching and the manufacture of poultry grit and lime for other industries.

A review of the systematic position of the species of the genus *Ostrea* of the Philippines is embodied in this report.

A general information of the life history of the oyster together with a discussion of the intensity of spatting, feeding of oysters, as well as essential factors affecting production is discussed in this paper.

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ILLUSTRATIONS

PLATE 1

Layout of the Binakayan Oyster Experimental Farm showing the different methods of cultivation: A, oysters grown by the stick (tulus) method; B, oysters grown by the hanging (bitin) methods; C, oysters grown by the line (sampayan) method; D, oysters grown by the tray (bangsal) method.

PLATE 2

Sections of oysters plots with long lines of oysters, showing sampayan method.

PLATE 3

A view of the oyster laboratory building and oysters grown horizontally on a plot 120 meters long.

PLATE 4

Lateral views of two oyster plots, oyster cultch used are 2.5 ft. long placed horizontally on the plots.

PLATE 5

Stored bundles of oyster cultch, wire trays, samples of oyster cultch (tulus and wire) and oyster samples attached to tulus and wire cultch.

PLATE 1.

PLATE 2.

PLATE 3.

PLATE 4.

PLATE 5.

THE CULTIVATION OF SUGPO (PENAEUS MONODON FABRICIUS) IN THE PHILIPPINES[1]

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TWO PLATES

INTRODUCTION

Sugpo (Plate 1, fig. 1), a kind of shrimp known scientifically as *Penæus monodon* Fabricius, is now cultivated on a commercial scale in Philippine estuarine fishponds either together with the bañgos, *Chanos chanos* (Forskål), or separately by itself. Considered a table delicacy, sugpo commands the highest price among the shrimps being sold in the local markets. A kilo which generally contains from eight to twelve individual sugpo, measuring from six to ten inches long, costs as much as eight pesos.[2] A hectare of fishpond on the average can produce around three hundred and fifty kilos of sugpo of marketable size after six months of cultivation.

Sugpo is being caught with other shrimps in the open sea by means of trawls operated in connection with powered fishing vessels of over 3 tons gross. The composition of the shrimp catches of these vessels reveals the presence in great quantities of *Penæus indicus* Milne-Edwards, *P. canaliculatus* Olivier, *P. affinis* Milne-Edwards, *P. incisipes* Spence-Bate, and *P. monodon* Fabricius. In this connection it has been noted that in all these catches sugpo is always much less in number compared with the other shrimps.

The rostrum of the sugpo is straight, dorsally elevated into a laterally compressed crest. The rostral formula is $\frac{6-7}{3}$, that is, 6 to 7 teeth lined along the upper margin and 3 teeth on the lower edge of the rostrum. The antennular scales reach beyond the eyes and the longer antennular flagellum is shorter than the peduncle. The fourth to the sixth abdominal segments

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[2] One peso, Philippine currency, is equivalent to fifty cents, United States currency.

are carinated on the middorsal line. The male is differentiated from the female by the presence of the petasma, a membranous development of the endopodites of the first pair of its pleopods. The male genital opening is situated at the coxopodites of the fifth pair of pereiopods. The female, on the other hand, has its sternum divided longitudinally into a median cleft, immediately between the fifth pair of pereiopods. The sides of this cleft appear as a flattened calcified plate called the "thelycum." This structure extends from the base of the coxopodites of the fourth pair of pereiopods to the posterior border of the sternum. The female genital opening is located on the coxopodites of the third pair of pereiopods. The exopodite of the first pair of pleopods is long and flat, while the endopodite is less developed, appearing like a small bud.

In life the sugpo fry can be easily recognized from any other penaeids because of its dark color. The body of a sugpo fry is almost black except the dorsomedian longitudinal plane which is light brown. The antennæ and antennules are divided into small cylindrical alternating black and white bars. Almost all of these beautiful colorations disappear as the sugpo grows except for the black bars striating the antennules.

The general appearance of a sexually mature sugpo is deep green. The edges of the pleopods are fringed with short, fine, orange-red hair. The outer surface of both the pereiopods and pleopods has two irregular yellow blotches. There are about six arched horizontal almost black bands cutting across each segment and extending from side to side. These are permanent external markings of a live sugpo from the fry stage to sexual maturity.

The movements of the sugpo in the water are effected by means of a backward and forward sculling movements of the pleopods or swimmerets. When on the bottom undisturbed, it may be seen wading on the mud by either the combined movements of the pereiopods and pleopods or each of these functioning independently of the other. The animal raises its cephalothorax at about an angle of forty-five degrees with the level of the bottom, the sixth somite comprising the telson and uropods hanging low trailing on the ground. While at this position and when intruded upon, the abdomen is folded U-shaped in preparation to throw itself forward or backward in short sudden jerks.

The sugpo, like any other crustacean, grows when it molts. The bigger sugpo after shedding off its hard shell lays still,

almost motionless for sometime until the exoskeleton attains its normal state of hardness. On the other hand, sugpo fry immediately after throwing off their shell move about as actively as before the shedding off of the hard shell. While molting the hard or old shell is disrupted dorsally at a point between the cephalothorax and the first somite. The head comes out first and almost simultaneously the appendages and the body are released at the same time.

FEEDING HABITS OF SUGPO

The sugpo is a plankton feeder although most often it is also carnivorous. In glass aquaria the sugpo feeds on small bits of shrimps and fishes. The food is seized by the pincers and is then pushed back into the mouth. In the pond the sugpo may be seen nibbling on algæ (lumut). Considering the small size of its digestive system, the plant and fish food consumption during its life time is probably very small. An examination of stomach contents of some sexually mature sugpo revealed the presence of fish fragments, bits of crustaceans, filamentous blue green algae, diatoms and mud particles.

Sugpo in all its life stages, especially during its fry stage, relishes plankton (lablab) food. Lab-lab is a biological association of minute plants and animals growing on the mud floor of fishponds. Rabanal in 1949 listed the following as the components of lab-lab.

I. Plant components.
- Division—Thallophyta.
  - Subdivision—Fungi.
    - Class—Schizomycetes.
      1. Bacteria—Cocci, baccilli, and spirilli.
    - Class—Myxophyceæ (blue-green algæ).
      - Order—Cocogenales—One-celled or colonial forms, not filamentous.
        - Family—Chroococcacæ.
          1. Chroococcus.
      - Order—Homogonales—filamentous forms.
        - Family—Oscillatoriacea.
          1. Oscillatoria.
          2. Spirulina.
          3. Phormidium.
          4. Lyngbya.
        - Family—Nostocacæ.
          1. Anabaena.
    - Class—Bacillariophyceæ—the diatoms.
      - Order—Centrales—Discoid forms.

Family—Achnanthaceæ.
1. Achnanthes.
2. Coconeis.
Family—Naviculaceæ.
1. Pleurosigma.
2. Gyrosigma.
3. Pinnularia.
4. Navicula.
5. Mastogloia.
6. Amphipleura.
7. Amphiprora.
8. Stauroneis.
9. Diploneis.
Family—Nitzschiaceæ.
1. Nitzschia sigma.
2. Nitzschia closterium.
Family—Surtrellaceæ.
1. Surirella.
2. Camphylodiscus.
Family—Fragilariaceæ.
1. Fragilaria.
Family—Gomphonemataceæ.
1. Gomphonema.
Class—Chlorophycea.
Order—Ulothricales.
Family—Cladophoraceæ.
1. Cladophora.
2. Chaetomorpha.
Order—Ulvales.
Family—Ulvaceæ.
1. Enteromorpha intestinalis.

II. Animal components.
Phylum—Protozoa.
Class—Mastigophora (Flagellata).
Order—Phytomonadida.
Family—Chlamydomonadidæ.
1. Carteria.
Class—Sarcodina (Rhizopoda).
Order—Lobosa (moebaea).
Family—Amoebidæ.
1. Amoeba.
Class—Infusuria (Ciliata).
Order—Holotrichida.
Family—Holophyryidæ.
1. Coleps.
Family—Trachelliidæ.
1. Deliptus.
Family—Ophryoglenidæ.
1. Colpidium.

Order—Hypotrichida.
Family—Plagiotomidæ.
1. Spirostomum.
Family—Oxytrichidæ.
1. Oxytricha.
2. Stylonychia.
3. Stychotricha.
Family—Euplotidæ.
1. Euplotes.
Order—Peritrichida.
Family—Vorticellidæ.
1. Vorticella.
Order—Heterotrichida.
Family—Stentoridæ.
1. Folliculina.
Phylum—Platyhelminthes—flatworms.
Class—Turbellaria.
Order—Polycladida—Larger forms with intestine much branched. Common.
Phylum—Nemathelminthes—round worms.
Class—Nematoda—Free-living worms. Common.
Phylum—Rotifera—The rotifers or wheel animacules. Several forms. Common.
Phylum—Mollusca.
Class—Gastropoda.
Order—Pulmonata.
Phylum—Annelida.
Class—Chaetopoda.
Subclass—Polychaeta—Larvae and adults represented
Phylum—Arthropoda.
Class—Crustacea.
Subclass—Entomostraca.
Order—Copepoda—Several forms and at various stages
Order—Ostracoda.
Subclass—Malacostraca.
Order—Amphipoda.
Order—Decapoda—Larval forms only.
Class—Insecta.
Order—Diptera—Larval forms.
Order—Coleoptera—Larvae and adults.

SUGPO FRY

Migration of sugpo fry.—Sugpo fry generally appear along the shores of Manila Bay in the early part of May. Every year they are found in abundance in the same place from May to October. They measure from 10.0 to 15.2 millimeters or an

average length of 12.6 millimeters. They are being caught in almost all places in the Philippines where bañgos fry are also found. Sugpo fry make their way into tidal rivers, creeks, lagoons, and other shallow places with brackish water by means of the incoming water due to high tide. It has also been observed that in masses of drifting seaweeds are often found many sugpo fry attaching to them as they are carried to the shores by the inflowing current from the open sea. It has been noted too that sugpo fry are abundantly found clinging about various hydrophytic flowering plants and semiaquatic grass of the family Gramineae growing in swampy places below the tide line immediately after storms which usually occur in the months of June, July and August. The sugpo fry migrate towards the shore and into brackish waters for feeding and shelter. They stay in those places for a period of not less than six months when they return to the sea to spawn.

Sugpo fry fishery.—Sugpo fry, like the bañgos fry, are now a distinct and lucrative fishery in many places in the Philippines where they are being caught. An experienced fisherman can catch as many as from 400 to 1,500 sugpo fry a day. The catches are sold to fish farm owners at three to five pesos per hundred.

A sugpo fry collector uses a small banca, a large earthen jar, a white large-mouthed porcelain bowl and a triangular dip net. The collector usually sits in the stern hold of his banca towards the prow. The banca is kept in motion and its course determined by a wooden steer which is set on one side of the boat as the collector paddles on the other side to maintain the direction of the course. This wooden steer serves as a robot steersman, thus saving the employment of an extra man.

The large earthen jar is preferred because it is highly permeable and keeps the water in it cool all the time. It is provided with tiny holes about its greater surface diameter to allow the water to leak through. These devices serve as an aeration and at the same time prevent the overflow of the water as it is being poured from time to time in small amounts into the jar. A few dry twigs or shredded banana leaves are placed inside the jar for the sugpo fry to cling on. Precaution is, however, taken in choosing the right kind of twigs to use as the sugpo fry are very sensitive to some plant saps which are often toxic to them.

The white porcelain bowl is used for transferring the sugpo fry from the dip net into the earthen jar because their presence

is easily detected in a container with a white background. In a receding tide the white porcelain bowl becomes very handy in collecting sugpo fry left in very shallow waters. This method of collecting sugpo fry is very strenuous as a collector has to move from one place to another for the purpose of hunting for the fry. Besides, during the months of June, July, August, and September the water is usually turbid thus making it very difficult to detect the presence of sugpo fry under three inches from the surface of the water.

Collecting sugpo fry is made easier with the use of bundles of twigs or grass tied to a long rope line at an interval of about two meters. A sugpo fry collector at frequent periods visit the device for collecting the fry. A dip net is scooped beneath the individual bunches and as the former is being raised each bunch is shaken to liberate the sugpo fry. Experienced collectors catch as many as 10 sugpo fry from an individual bunch at a time. Collecting sugpo fry by means of this method is also done at night with the use of light or flashlight.

THE CULTIVATION OF SUGPO

Preparation of sugpo fry nursery.—The success or failure of the cultivation of sugpo depends mostly on the manner a sugpo fry nursery is prepared. A well prepared nursery (Plate 1, fig. 2) is free from predacious animals like water snakes (*Chersydrus granulatus*), apahap (*Lates calcarifer*), ten pounder (*Elops hawaiensis*), tarpons (*Megalops cyprinoides*), biang puti (*Glossogobius giurus*), mudskippers (*Periophthalmus schlosseri* and *P. barbarus*), bengal swamp eels (*Synbranchus bengalensis*), silver piko eels (*Muraenesox cinereus*), and igat or eel gobies (*Taenioides gracilis*). Crustaceans such as crabs belonging to the families Portunidæ, Grapsidæ, Potamonidæ and Ocypodidæ must likewise be carefully eliminated as they are also heavy feeders on sugpo fry.

A sugpo fry nursery pond is usually the smallest compartment in a brackish-water-fishpond system. The size varies according to the amount of capital invested in the project by the individual fishpond owner. However, nursery ponds measuring not bigger than 17 by 17 meters are common especially in regions bordering Manila Bay. Each pond has wood gates, 1.5 to 2 feet wide, which are provided with wood slabs to control water and also with fine-meshed bamboo screens covered with abaca cloth (sinamay) to prevent the entrance and exit of sugpo fry and also of predatory species.

About four to six weeks before the nurseries are to be stocked they are first cleaned, drained and sunned until the floor cracks to dryness. The bottom of each pond is thoroughly levelled and during the process of levelling all those predacious animals not killed by exposure to sunshine are carefully collected and killed. This process is accomplished in about a month or so depending on the condition of the weather. If there is sunshine everyday the whole process could be finished in a shorter period of time. A week after the bottom is levelled, tidal water is allowed into the pond to a depth ranging from 3 to 10 centimeters. This height of water is maintained inside the pond even after freshening each pond with new tidal water. All these conditions are conducive to a luxuriant growth of lab-lab and in about less than a month the nursery pond will be ready for planting with sugpo fry.

Stocking sugpo fry in the nursery.—In stocking a nursery pond with sugpo fry, each jar container is carefully set in the water, the mouth tilted to one side until the fry are able to swim out. Stocking is done during the coolest part of the day when the temperature of the water in the nursery pond approximates that of the water in the jar. It has been found that late afternoon or early in the morning is the best time for planting sugpo fry in the nursery.

Care of the sugpo fry.—After stocking the nursery pond its water is increased and maintained to about a foot in depth. At frequent periods freshening is done by means of letting out the stagnant water during low tide and then admitting in new water at high tide. During this process the sluice gate is carefully screened to prevent the escape of sugpo fry and the entrance of harmful animals.

Small bundles of dry twigs are placed inside the nursery ponds for the tiny sugpo fry to cling on. They are better observed while clinging about the twigs and measurements of representative samples to determine their rate of growth are facilitated by just raising the twigs attached with sugpo fry. In this connection it has been found that after the sugpo has attained a size of about 54 millimeters long they lose their clinging instinct.

Filamentous algae should not be allowed to grow inside a nursery pond because once the sugpo fry get entangled with the filaments of the algae they cannot release themselves and eventually die. Besides, lumut growth is always very thick such that it prevents the free movements of sugpo fry especially

when these like to be at the bottom of the pond to stay away from the excessive heat of the sun.

Preparation of the sugpo rearing pond.—The rearing pond (Plate 2, fig. 1) is generally located adjacent to the nursery pond to facilitate planting. The regular size of this pond is around half a hectare to one hectare. Its sluice gates are properly screened to prevent the escape of young sugpo and the entrance of harmful animals. Before the pond (Plate 2, fig. 2) is stocked with young sugpo, it is drained, cleaned, and allowed to dry for at least a week so that all their enemies are killed. The rearing pond may be planted with algae which serves as food for the growing sugpo and also for the bangos fingerlings which are generally reared in the same pond. The water inside the rearing pond is changed from time to time by taking advantage of tidal changes.

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ILLUSTRATIONS

PLATE 1

FIG. 1. Picture of sugpo.
2. A system of nursery ponds for sugpo fry.

PLATE 2

FIG. 1. A series of sugpo rearing ponds.
2. A sugpo rearing pond undergoing preparation.

1

2

PLATE 1.

1

2

PLATE 2.

THE YOUNG OF SOME FISHES OF LUZON [1]

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Of the Bureau of Fisheries, Manila

THIRTY-FIVE TEXT FIGURES

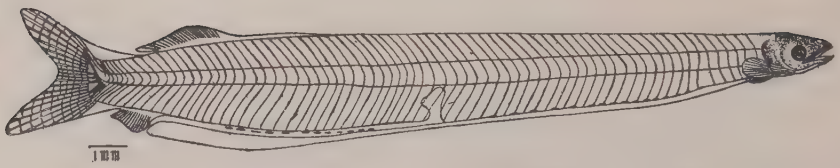
In this paper are given the descriptions of thirty-five post-larval stages of some fishes belonging to the families Elopidæ, Chanidæ, Cyprinodontidæ, Phallostethidæ, Hemiramphidæ, Exocoetidæ, Soleidæ, Mugilidæ, Apogonidæ, Kyphosidæ, Serranidæ, Theraponidæ, Platycephalidæ, Scatophagidæ, Scaridæ, Eleotridæ, Gobiidæ, Blennidæ, Balistidæ, Tetraodontidæ, and Diodontidæ which were mostly collected by the writers in April and May 1949 from northwestern Luzon. A portion of the material from the Bureau of Fisheries, Dagat-dagatan Salt-water Fishery Experimental Station, Malabon, Rizal Province, is also included in this report.

ELOPIDÆ

ELOPS HAWAIENSIS Regan. Ten pounder (bidbid, awa). Text fig. 1.

Specimen 18 millimeters long.—The larval ten pounder is transparent, with flattened, narrow and elongate body of 65 to 70 myotomes; depth 7.3 in standard length; head small and undeveloped, 11 in length; snout pointed, 2.6 in head; eyes midlateral, 5 in head; mouth oblique; angle of the maxillary beneath anterior third of the eye diameter. There are 5 branchiostegals on the lower portion of the opercle. The dorsal fin which is near the caudal fin has a trace of the dorsal finfold at the anterior portion and also traces of soft rays in the dorsal fin lobe. The anal fin lobe is small with the beginning of soft rays. Anterior to the vent is the long narrow ventral fin fold which still exists at this stage. The homocercal caudal has 24 rays attached to the upturned urostyle, epurals, and hypurals. The caudal peduncle is as long as narrow and has still the remnants of the dorsal and ventral fin folds. Few pigments are on the head, the ventral sides of the body, and between the myomere segments.

[1] This is the second paper on the juvenile fishes of Luzon. Presented by the Philippine Delegation before the Second Meeting of the Indo-Pacific Fisheries Council held at Cronulla, N. S. W., Australia, April 17–28, 1950. Submitted for publication June 5, 1950.



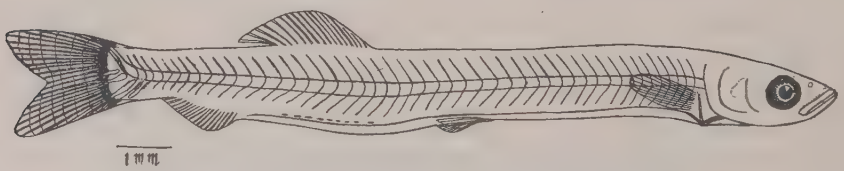
TEXT FIG. 1. *Elops hawaiensis.* From a specimen 18 mm. long.

Four specimens, 20 to 27 millimeters long, were collected in June 1946 by Mr. Herminio R. Rabanal at the Dagat-dagatan Lagoon, Malabon, Rizal Province, Luzon.

CHANIDÆ

CHANOS CHANOS (Forskal). Milkfish fry (kawag-kawag, bugui). Text figs 2 and 3.

Specimen 12.5 millimeters long.—The postlarval fish has well-developed head with oblique mouth, lateral eyes, preopercle and opercles. The elongate and compressed body has undeveloped pelvic, dorsal, and anal fins; the forked caudal has about 20 caudal rays. There are about 53 or more myotomes traversing the midlateral notochord.



TEXT FIG. 2. *Chanos chanos.* From a specimen 12.5 mm. long.

The young fish was included in some of the coral reef juvenile fishes collected at Buraan Tidal Creek, Burgos, Ilocos Norte Province, on May 20, 1949.

Specimen 13.5 millimeters long.—The milkfish fry when about one to two weeks old in the nursery ponds are no longer needlelike. Body tapers posteriorly; depth 5.6 in standard length; head pointed and well developed, 3.5 in length; snout long and angular, equals eye diameter which is 3.5 in head. Eyes midlateral; mouth oblique and angle of maxillary not reaching anterior edge of eye socket; opercles broad and round edged, with branchiostegals at their ventral edge. Dorsal XII, anal VI; caudal of 20 rays deeply forked. A narrow remnant of the ventral fin fold is between the pelvic fin and anal fin, just anterior to the cloacal opening. There are no traces of

scales except of fifty-one myomeres and a distinct lateral line along the side of the body. At the base of the caudal fin are the upturned notochord, urostyle, epurals, and hypurals upon which the caudal rays are attached. Abdominal cavity elongate, at the posterior portion of which is the vent. Head and anterior half of the body pigmented with chromatophores.

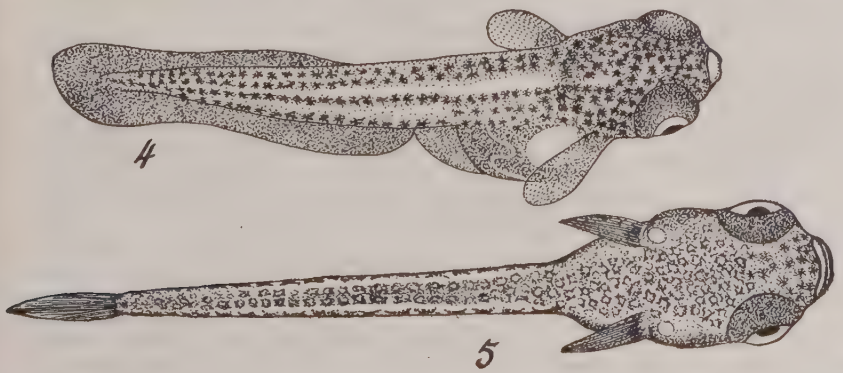
TEXT FIG. 3. *Chanos chanos.* From a specimen 13.5 mm. long.

Several specimens, 12.5 to 24 millimeters long, were collected by Mr. Herminio R. Rabanal in June 1949 from the Dagatdagatan Lagoon, Malabon, Rizal Province, Luzon.

CYPRINODONTIDÆ

APLOCHEILUS LUZONENSIS Herre and Ablan. Cyprinid (coscosleng). Text figs. 4 and 5.

Specimen 5 millimeters long.—Body elongate with an absorbed yolk sac with streaming developing alimentary canal. Head 4.66 in total length, well developed with dorsolateral bulging pair of eyes which are 2.5 in head; mouth small, transverse; teeth wanting; snout narrow. Pectorals well developed, leptocercal caudal still exists as the dorsal fin starts from the middorsal portion of body around the caudal and continues



TEXT FIGS. 4 & 5. *Aplocheilus luzonensis.* From specimens 5 to 7 mm. long.

with a notch to the posterior edge of the yolk. Characteristic pigments on the head and dorsolateral sides of the body are numerous stellate chromatophores which are parallel at the anterior series and posterior parts of the body.

Specimen 7 millimeters long.—Body elongate with absence of the continuous fin fold; with a reduced yolk as indicated below the pair of pectorals below the opercles; pair of eyes still undeveloped in the head which is 2.5 in head. Transverse mouth small, snout narrow. Dark stellate chromatophores which are irregular on the head region parallel on the dorsal and sides of the body (fig. 5).

Specimens, 5 to 12 millimeters long, were collected at the Pagsanjan River, Laoag, Ilocos Norte Province, on October 18, 1949.

PHALLOSTETHIDÆ

NEOSTETHUS sp. Cyprinodont fish. Text fig. 6.

Specimen 8.5 millimeters long.—The postlarval cyprinid is laterally compressed in body; depth 5.33 in standard length; head moderate, not sharply pointed, 4 times in length; snout short, 4.5 in head; eyes midlateral and oblique; angle of the maxillary of the jaws on level with the edge of the diameter. The single dorsal of VI spines is nearer the caudal; ventral fin of 16 soft rays originates from the ventral midportion of the entire length of the fish and its base is twice the length of the dorsal base of the dorsal fin. The specific numbers of dorsal and anal fin rays place this specimen under the genus *Neostethus*. Anterior to the anal fin is the female organ, oviduct, and anus below the abdominal region.

TEXT FIG. 6. *Neostethus* sp. From a specimen 8.5 mm. long.

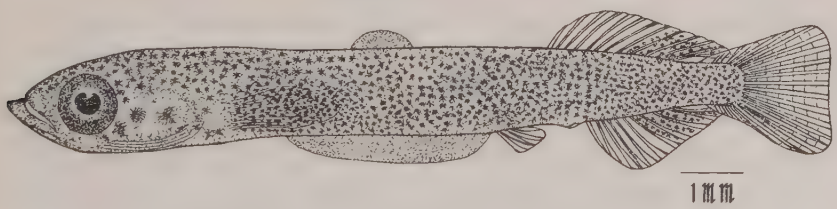
The specimen is pale yellowish brown in alcohol but there are a few stellate pigment spots on the opercle and on the head, and on the dorsal edge of the body. The forked homocercal caudal of 20 rays is equal to the length of the long and narrow peduncle; its membranes are regularly spotted with transverse pigments.

Fourteen specimens, 8.5 to 26 millimeters long, were collected by Mr. Herminio R. Rabanal on July 13, 1949, at the Dagatdagatan Lagoon, Malabon, Rizal Province, Luzon.

HEMIRAMPHIDÆ

HEMIRAMPHUS sp. Halfbeak (bugin, barasot, buloy). Text fig. 7.

Specimen 11 millimeters long.—Body elongate, cylindrical but slightly compressed; height 7.66 in length. Head 3.66 in length; mouth oblique with a protruding lower jaw, the beginning of the long beak; snout convex, 1.75 in eye diameter which is almost 3 in head length. Dorsal I–11; anal I, 9; both near the truncate caudal fin of 15 principal rays; pelvic fin small, near anterior of anus just behind the narrow but long remnant of the ventral fin fold opposite. At the midportion of the body is a small lunar dorsal fin, a remnant of the fin fold. Pectoral fin narrow, pointed, reaching the anterior level of the embryonic remnant of the dorsal fin fold.



TEXT FIG. 7. *Hemiramphus* sp. From a specimen 11 mm. long.

The entire postlarval fish is heavily pigmented with stellate chromatophores on the head, entire body and posterior portions of the dorsal and anal fins. In alcohol the fish is blackish with yellowish orange tinge on body and on the dorsal and anal fins.

The only specimen was collected from Pugus, Cabugao, Ilocos Sur Province, on April 19, 1949.

ZENARCHOPTERUS sp. Halfbeaks (bugin, barasot, buloy). Text fig. 8.

Specimen 20 millimeters long.—Postlarval halfbeak elongate, slender, nearly cylindrical, slightly and laterally compressed in body; depth 11.25 in standard length; lower beak 6 millimeters long, 1⅔ the head. Eyes are lateral, separated by a broad occipital area, 7 in head; mouth oblique with a rounded upper mouth lid that fits tightly on the buccal cavity of the lower extended beak. Head with the lower beak 1.2 in standard length. Dorsal and anal fins near the caudal fin; pelvic fin near the anal fin. Beak, head, and lateral sides of the body covered with pigments of dots and stellate chromatophores.

Color of this specimen is red-orange to brownish black on the dorsal and anal fins.

TEXT FIG. 8. *Zenarchopterus* sp. From a specimen 20 mm. long.

Several specimens, 20 to 30 millimeters long, were collected at the Dagat-dagatan Lagoon, Malabon, Rizal Province, in June, 1946.

EXOCOETIDÆ

PAREXOCOETUS BRACHYPTERUS (Richardson). Flying fish. (bolador, balang). Text figs. 9 and 10.

Specimen 6 millimeters long.—The larval bolador has a robust body; depth 4 standard length; head large, 3 in length; mouth nearly vertical; angle of the maxillary beneath the anterior third of the eye diameter which is 2.5 in head; snout small, 4.5 in head; the preopercle and opercle rounded in outline without spines. Dorsals X, anal 8. They are near the

TEXT FIG. 9. *Parexocoetus brachypterus.* From a specimen 6 mm. long.

caudal fin of asymmetrical lobe of 24 rays; pectorals with 9 rays and pelvic fin with 6 rays.

At this stage there are no traces of scales. Stellate chromatophores are on the dorsal, midlateral, ventral, and abdominal sides of the body. Such pigments are also sparsely located on top of the head, on the preopercle and opercle.

The specimens preserved in alcohol are yellowish cream with olive brown to blackish pigments on the naked skin of the body.

Specimen 11 millimeters long.—Body robust, cylindrical and elongate and has body proportions as in the adult; depth 4.33

in standard length; head small and slightly depressed above; mouth strongly oblique but not decidedly vertical as the 6 millimeters larva; angle of the maxillary a little beyond anterior of eye socket; snout small, 4.5 in eye diameter which is 2.5 in head; preopercle and opercle semirounded in outline; branchiostegals 5. All the fins are well developed; dorsal X, and 6, ventral 5; pectorals 10 and caudal of two unequal lobes, upper

TEXT FIG. 10. *Parexocoetus brachypterus.* From a specimen 11 mm. long.

short lobe of 12 rays and lower long lobe of 12 rays. The three last longest rays of the lower lobe are twice as long as the shortest rays of the upper lobe. The margin of the fins are strongly oblique. Pigmentations are of dark-brownish, stellate chromatophores on the sides, dorsal as well as ventral sides of the body upon a yellowish cream naked background. Stellate chromatophores are on the membranes and spines of the pectoral, dorsal, ventral, and anal fins.

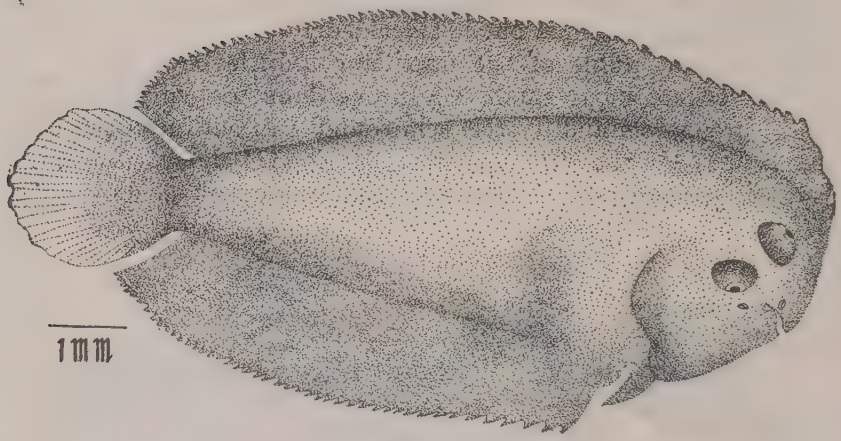
Ten specimens, 6 to 22 millimeters long, were collected at the Dagat-dagatn Lagoon, Malabon, Rizal Province, on July 13, 1949.

SOLEIDÆ

SOLEA HUMILIS Cantor. Ovate sole (tambiki). Text fig. 11.

Specimen 8 millimeters long.—The larval fish is ovate, flattened and compressed in body; depth 2.5 in length; head indistinct, 3.33 in length; mouth hooks down on right lateral side; opercle skin covering distinct. Dorsal fin continuous, with 70 serrations; anal also continuous, with 44 serrations; caudal rounded with 16 rays, separated from dorsal and anal fins by a short caudal peduncle. Lateral line is not very distinct in this stage. Minute brownish dots cover entire head, fins and body on right side; left side colorless or white transparent.

The single tongue fish was collected from Buraan tidal creek, Burgos, Ilocos Norte Province, on May 5, 1949.



TEXT FIG. 11. *Solea humilis*. From a specimen 8 mm. long.

MUGILIDÆ

MUGIL sp. Mull t (banak, liza, talilong, lapes, risec) Text fig. 12.

Specimen 6.3 millimeters long.—The body is elongate, cylindrical and slightly compressed, height 3.66 in length, head convex almost 3 in length. Eyes is dorsolateral, 2.6 in head length; mouth slightly oblique, angle of maxillae reaching beneath perpendicular anterior edge of eye. Space between dorsal of opercle broad and convex; branchiostegals 5. Dorsal V, 1–7; anal I, 6. Caudal peduncle is 1.5 as long as broad; caudal fin with 16 rays, truncate; ventral fin terminates on level of longest upper tip of pectoral.

TEXT FIG. 12. *Mugil* sp. From specimen 6.3 mm. long.

This specimen is naked and also characterized by the presence of epidermal branching blood capillaries on all sides of the body. There are stellate chromatophores on the cheek and on the dorsal side below the spines of the dorsal fin. Alcoholic specimens are creamy to yellowish brown in color.

Four specimens of larval mullets were collected from Buraan tidal creek, Burgos, Ilocos Norte Province, on May 5, 1949.

APOGONIDÆ

APOGON sp. Cardinal fish (bagsang taaw, bunka, benka). Text fig. 13.

Specimen 8.75 millimeters long.—The body is deep and compressed; depth 2.5 in length; head large, pointed, triangular, 2.3 in length; mouth oblique, angle of maxillary beneath mid-diameter of eye socket which is 2.6 times in head length; snout short, almost 4 in head. Preopercle is serrated; upper midportion of opercular edge with a spine; and below lower portion of opercle are a few branchiostegals. Dorsal VI, 1–9; anal I, 9; caudal forked with 20 rays; peduncle 1.5 as long as broad. Scales are large, covering anterior sides of body;

TEXT FIG. 13. *Apogon* sp. From a specimen 8.75 mm. long.

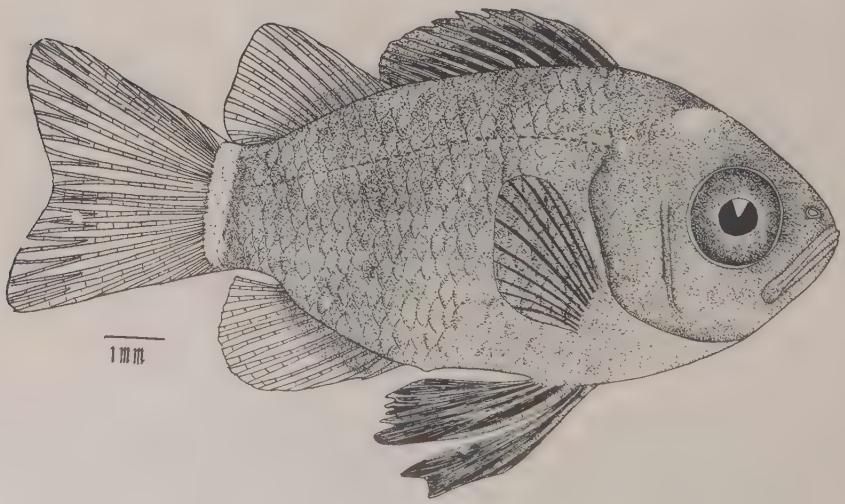
region of peduncle naked with a group 5 stellate pigments on the base of the caudal fin; transverse rows of stellate pigments located on anterior caudal peduncle; stellate chromatophores at the bases of the anal fins. Group of pigment spots on top of the head and a few groups of stellate chromatophores on the preopercle and opercles, one beneath the nostril on the snout and a series of spots under lower jaw. Membranes of dorsal, ventral, and anal fins pigmented. The fish is entirely brownish to blackish in alcohol.

Several specimens were collected at Buraan, Burgos, Ilocos Norte Province, on May 5, 1949.

KYPHOSIDÆ

KYPHOSUS VAIGIENSIS (Quoy and Gaimard.) Rudder fish (ilak, ilec). Text fig. 14.

Specimen 10.5 millimeters long.—The body is deep and compressed; depth 2 in standard length. Head is large and convex, 2.5 in length; mouth oblique; angle of maxillary beneath and parallel to the edge of eye socket which is 2.5 in head; snout is short, 1.5 eye diameter. Opercle with smooth rounded edge; preopercle minutely serrated. Dorsals notched XII, I–12; anal III, 12; caudal of 24 rays, shallow forked; pelvic fins with sharp outer spines and eight long soft rays connected by black thin membranes. Lateral line high up following the arc of the dorsal body contour. The ctenoid scales on the body are large, 30 on lateral series, 15 on transverse series. Scales on the head, membranes of the spinous dorsal and the bases of the second dorsal and anal fins are dark pigmented. Scales on the



TEXT FIG. 14. *Kyphosus vaigiensis.* From a specimen 10.5 mm. long.

third portion of the base of caudal peduncle are of creamy brownish in color.

The only advanced larval fish was collected at Buraan tidal creek, Burgos, Ilocos Norte Province, on May 20, 1949.

SERRANIDÆ

EPINEPHELUS FUSCOGUTTATUS (Forskal). Marbled grouper (garopa). Text fig. 15.

Specimen 16 millimeters long.—The body is deep, compressed; height 1.8 in length; head 1.25 in length, slightly convex with an oblique mouth and concave snout. Eye is dorsolateral, 3.25 head length. Preopercle is serrated, with three big spines followed by five smaller spines. Lower angle of opercle with 5 branchiostegals. Dorsal XI–16; anal III, 12; pectorals short; caudal fin with 18 rays, rounded. The entire larval fish is leaflike brownish cream with black pigment spots on the head, all sides of body on the dorsal, ventral, anal fins and on the anterior half of caudal.

TEXT FIG. 15. *Epinephelus fuscoguttatus.* From a specimen 16 mm. long.

Four specimens, 16 to 20 millimeters long, were collected from Dagat-dagatan Salt Water Fishery Experimental Farm in 1947.

EPINEPHELUS MORRHUA (Cuvier and Valenciennes). Sea bass (garopa). Text fig. 16.

Specimen 10 millimeters long.—The body is elongate and compressed; depth 2.9 in standard length. Head is short and convex, 3 in length; mouth is small and slightly oblique; angle of maxillary not reaching parallel edge of anterior eye socket; snout, small, convex, 2 in eye diameter which is 2.5 in head. Opercle is unarmored and of square edge. Dorsals continuous, X–10; anal II, 10; caudal with 24 rays, truncate. Five unequal

parallel lateral bands of olive brown to black dot pigments are on the sides of the body; the first starts on the head and extends dorsally to the base of the caudal peduncle; the second is short and starts below the first dorsal spine and ends below third soft spine of second dorsal; the third starts from the snout and runs parallel but not reaching the end of the second parallel stripe; the fourth parallel stripe is broader than the first series of three stripes, beginning from the opercle and terminating to the dorsal third base of the caudal peduncle; the fifth parallel stripe is as wide as the fourth and starts at lower

TEXT FIG. 16. *Epinephelus morrhua.* From a specimen 10 mm. long.

half of the opercle and terminates at the third ventral base of the caudal base.

This single specimen was collected at Buraan tidal creek, Burgos, Ilocos Norte Province, on May 20, 1949.

THERAPONIDÆ

THERAPON PLUMBEUS (Kner). Silver theraponid (ayuñgin). Text fig. 17.

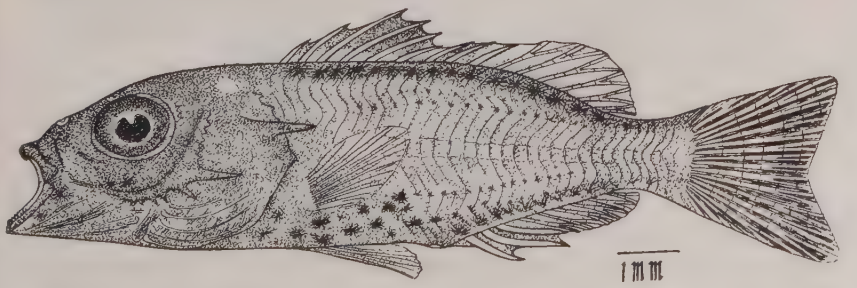
Specimen 16.5 millimeters long.—The body is deep, compressed; height 2.6 in length. Head is 2.5 in length; mouth oblique; angle of maxillary beneath midportion of diameter of dorsal lateral eye which is 3.25 in head length; snout triangular, 4 in head; preopercle serrated; opercle serrated at the upper edge followed by four moderate size spines on its outer border. Dorsal XI, 1–13, anal III, 8; pectoral 15; caudal with 20 rays, truncate. The entire fish is silvery black with minute scales on its body and with 6 narrow black transverse blotches. Dorsal fin membranes in between spines, dark pigmented; bases of soft dorsal and anal fins light pigmented. Soft rays of ventral fins with dark pigments.

TEXT FIG. 17. *Therapon plumbeus*. From a specimen 10 mm. long.

This single specimen was collected from Pugus, Cabugao, Ilocos Sur Province, on May 5, 1949.

THERAPON sp. Theraponid (baraoñgan). Text fig. 18.

Specimen 12 millimeters long.—This young theraponid is elongate and compressed in body. Head is 2.5 in standard length; mouth oblique; snout slightly convex; angle of maxillary not reaching anterior level of eye diameter; eyes dorsolateral, moderate in size. Preopercle armored with unequal spines, the posterior spine longest. Opercular spines on the upper portion of opercle still exist. Sharp spines and soft rays of notched dorsal and anal fins are developed. Pectoral fin short, not reaching level of notch of dorsal fin. Caudal peduncle 2 times as



TEXT FIG. 18. *Therapon* sp. From a specimen 12 mm. long.

long as broad. Caudal fin shallow forked with 14 long caudal rays. Stellate chromatophores are on inverted V–shaped myomeres on the lateral sides of the body. The entire fish is olive brown to black in color.

Several specimens in formalin, 12 to 15 millimeters long, were collected from Gabu tidal stream, Laoag, Ilocos Norte Province, on April 5, 1949.

SCATOPHAGIDÆ

SCATOPHAGUS ARGUS (Linnaeus). Spade fish (kitang). Text fig. 19.

Specimen 7.5 millimeters long.—The postlarval kitang has a deep, quadriangular and compressed body; depth 1.3 in standard length; head large, 2 times in length; mouth is small; angle of maxillary is midway between edge of eye socket and the snout; paired nostrils are protruding above the snout on level of the mid-anterior diameter of the eye, which is almost 3 in the head. The preopercle and opercle are with triangular and trapezoidal areas or plates which are grooved. The upper portion of opercle is with a long sharp spine and the ventral base of the preopercle is with a short spine. Dorsal continuous IX–16; anal IV, 12; pectoral, small and rounded; caudal is oblong with 20 rays.

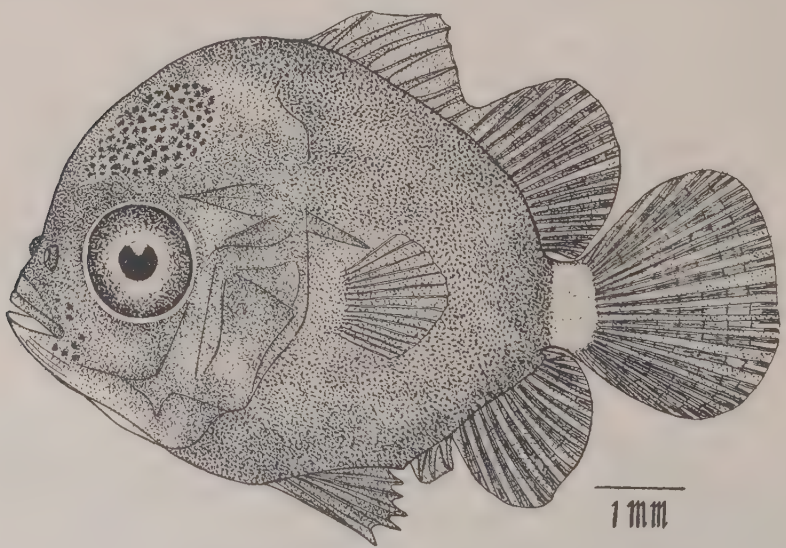


FIG. 19. *Scatophagus argus*. From 2 specimens 7.5 mm. long.

This specimen is olive brown with no traces of scales but dark pigment spots on the sides of the body. Larger groups of pigments are on the cranial region of the head and behind the maxillaries.

Forty-six specimens, 6 to 24 millimeters long, were collected at the Dagat-dagatan Experimental Fish Farm, Malabon, Rizal Province, on July 13, 1949.

PLATYCEPHALIDÆ

PLATYCEPHALUS sp. Flathead (sunog, uramuram, lacoy). Text fig. 20.

Specimen 7 millimeters long.—The body tapers posteriorly, rounded; depth 3.5 in length. Head is large, triangular in lateral; snout 2.5 in head, caving in with protruding nostrils; below level of mid-diameter of eye which is small and dorsolateral; snout 2.5 in head, caving in with protruding nostrils; branchiostegals 4. Preopercle serrated with three large lateral sharp spines. Dorsal VII–9; anal I, 8; pectoral long reaching beyond anterior 7th rays of anal; caudal truncate with 16 principal caudal rays. Pair of ventral fins large, tips also reaching first spinous rays of ventral. Entire larval fish olive black with very dark pigments on fins and on rounded spots on sides of body.

The only specimen was collected from the rocky shores of Buraan, Burgos, Ilocos Norte Province, on May 20, 1949.

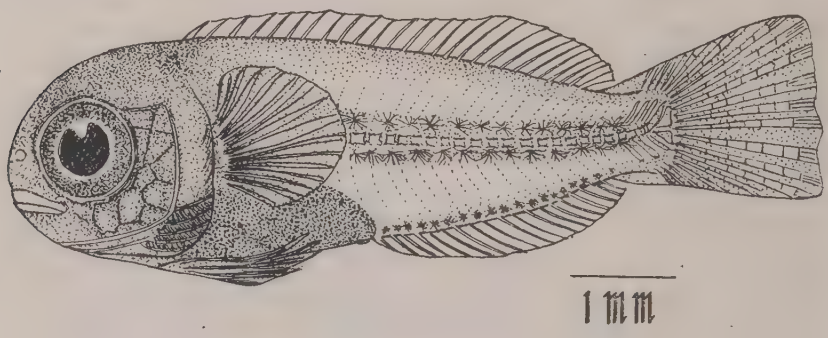
TEXT FIG. 20. *Platycephalus* sp. From a specimen 7 mm. long.

SCARIDÆ

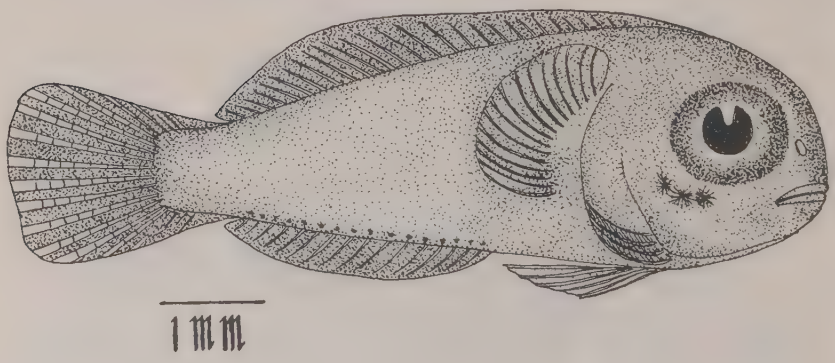
SCARUS sp. Coral fish (loro). Text figs. 21 and 22.

Specimen 6 millimeters long.—The young parrot fish has an oblong, moderately compressed and robust body. Head is short, moderately deep; mouth small, terminal; snout short; lower jaw spoon-shaped; eyes large, 2 in head. Trapezoidal areas or cheek bones are present in preopercle; opercular edge rounded with 5 branchiostegals. A 6-millimeter stage is transparent with traces of the vertebral column with the upturned urostyle. There are two rows of stellate chromatophores, the midlateral portion of the body and a row of stellate pigments above the base of the anal fin. Dorsal and anal fins are continuous, with traces of hard and soft rays; pectorals rounded; caudal with 12 long rays, truncate.

The juvenile fish, 6.5 millimeters long (fig. 22), has the body proportions as the above specimen but it is no longer transparent. Its head is dark with three stellate pigments



TEXT FIG. 21. *Scarus* sp. From a specimen 6 mm. long.



TEXT FIG. 22. *Scarus* sp. From a specimen 6.5 mm. long.

below the eye and a row of dot pigments at the ventral side of the body above the ventral fin. The body is cream in color.

The herbivorous adult species of the family Scaridae are mostly of large size, abundant in coral reef banks in nearly all tropical seas.

Numerous specimens were collected at Buraan tidal creek, Burgos, Ilocos Norte Province, on May 20, 1949.

ELEOTRIDÆ

EVIOTA sp. Eleotrid (Birot). Text fig. 23.

Specimen 11 millimeters long.—Body is elongate, compressed; depth 4 in standard length; head large, robust, conical, as long as high; eye 3 in head and 1.5 the short snout; mouth oblique, angle of maxillary reaches anterior level of eye; opercle entire,

rounded, preopercle indistinct; branchiostegals 4. Dorsal VI, I–9; anal I, 10; first dorsal moderately elongated, third, fourth and fifth the longest; second dorsal and anal fin similar in outline; pectoral fin long, narrow, nearly reaching anal pre-anal spine; pectoral fin has 11 rays, largest ray reaching perpendicular level of posterior base of first dorsal fin. Scales in longitudinal series 17 to 18; transverse scales in greatest depth 10. Peduncle 1.25 as long as broad; caudal with 14 long rays truncate.

There are on each side of the body four vertical blotches of olive to blackish pigments on the scales in each of the band. The scales of the interspaces are light pigmented. There are four groups of small chromatophores on the head, below and above the eye, posterior to the eye, and before the first spine of the first dorsal fin.

TEXT FIG. 23. *Eviota* sp. From a specimen 11 mm. long.

A close relative of this minute eleotrid is *Eviota sealie* Herre but they differ greatly in body pigmentations, number of scales on the longitudinal series, and type of caudal fin.

Species of *Eviota* are among the smallest living vertebrates which are abundant in the crevices of coral reefs of the South Sea Islands, northward to the Philippines and southern Japan. The generic characters are not well defined (Herre 1927).

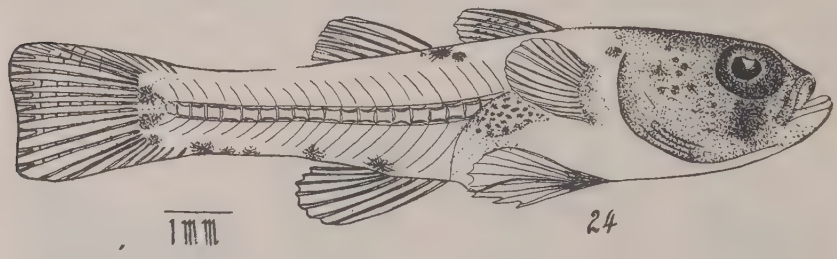
The only specimen, 11 millimeters long, was collected at a coral reef bank of Buraan tidal creek, Burgos, Ilocos Norte Province, on May 20, 1949.

GOBIIDÆ

VAIMOSA PIAPENSIS Herre. Goby fry (ipon). Text figs. 24, 25, and 26.

Specimens 8.5 millimeters long.—The transparent body is robust and elongate; depth 4.5 in standard length; the head a little convex; short and broad across opercles, 3.3 in length;

snout short, blunt, convex, broadly rounded, 2 in eyes, which is 3 in head. Eyes high up, dorsolateral; the mouth small, slightly oblique and the angle of maxillary beneath anterior third of eye. Branchiostegals 5. Caudal of 16 rays, truncate. Dorsal VI, 1–7; anal I, 7; pectorals of 14 rays, rounded. Pigmentations, dark on head region with a rounded black spot below the eye. The abdominal region with black spots. There are two chromatophores on dorsal side of body between the first and second dorsal fins and five chromatophores on the ventral side of body. Two rounded black spots are at the base of the caudal fin. There are also pigment spots on the first dorsal fin.



TEXT FIG. 24. *Vaimosa piapensis.* From a specimen 8.5 mm. long.

Specimen 10.5 millimeters long.—The body is robust and elongate; depth 4.2 in standard length; the head slightly convex, short and broad across the opercles, 3.25 in length; snout short, blunt, convex and broadly rounded, 2.5 in eyes, which is 3 in head. Eyes are high up and dorsolateral; mouth small and oblique; angle of maxillary beneath anterior third of eye. Dorsal VI, I–7; anal I, 7; pectorals of 14 rays, rounded and caudal of 16 rays, truncate. At this stage there are microscopic ctenoid scales with sparsely distributed pigment spots on the side of the body, the most significant of which are 3 small rounded black spots at the base of the caudal fin and two or three short but elongate black spots at the middle sides

TEXT FIG. 25. *Vaimosa piapensis.* From a specimen 10.5 mm. long.

of body. Small dot pigments are on the midmembranes of the spines of the first dorsal fin. A single chromatophore is on the anterior portion of the anal fin. The cheeks and opercles are pigmented; a single short and elongate pigment dot is below the eye, similar to that of *Chonophorus lacrymosus.*

Specimen 24 millimeters long.—The body is robust and elongate; depth 4.5 in standard length, head little convex, short and broad across the opercles, 4 times in length; snout, short, blunt, convex, broadly rounded, 1.5 in eyes which is 3.3 in head. Eyes are high up and dorsolateral; the mouth oblique and the angle of the maxillary beneath anterior third of eye. Dorsal VI, I–7; anal I, 7; pectorals with 18 rays and caudal with 20 rays, more or less rounded. At this stage the larval fish is similar to the adult form in every respect. The scales are ctenoid, 28 of which are on the longitudinal series and 8 to 9 are on the transverse series. Four groups of pigmented

TEXT FIG. 26. *Vaimosa pupensis.* From specimen 24 mm. long.

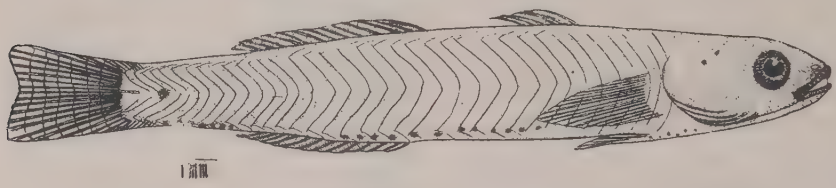
scales are on the dorsal sides of the body; four short and blunt pigments are on the midportion of posterior portion of body. Two rounded black pigments are at the base of the caudal fin. The membranes of the first dorsal are sparsely pigmented and the second dorsal fin with two rows of pigments spots on the fin membranes. The snout with a few black spots and below the eye is the *lacrymosus* spot of black pigments. The opercle with large scales and small black pigments on the branchiostegals.

Several specimens, 8.5 to 24 millimeters long, were collected at the Dagat-dagatan Lagoon, Malabon, Rizal Province, Luzon in June, 1949.

CHONOPHORUS OCELLARIS (Broussonet). Goby fry (ipon). Text figs. 27, 28, and 29.

Specimens 10 to 12 millimeters long.—The larval goby when caught at the mouth of rivers is colorless with a few melanophores on its head. On the ventral sides of the body and on each side of the caudal peduncle are pigment spots. A 12-milli-

meter stage has all the diagnostic character of the external characters of the adult with reference to the robust elongate rounded body with 38 myotomes, large long convex head. Dorsal VI, 1–10; anal I, 10; pectorals rounded; caudal fin slightly notched, with 14 long caudal rays. Mouth oblique, end of maxillary not reaching anterior level of eye diameter. Opercle rounded; branchiostegals 5.



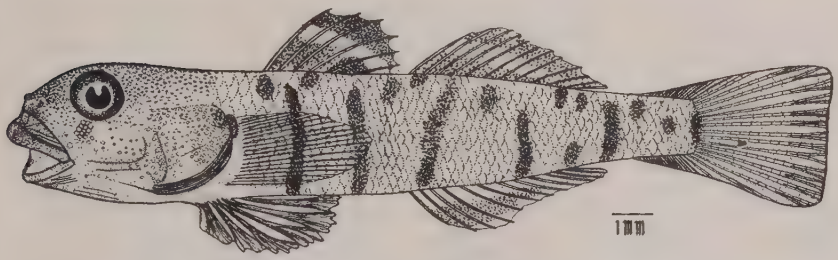
TEXT FIG. 27. *Chonophorus ocellaris*. From a specimen 10 mm. long.

Specimen 15 millimeters long.—Goby fry that have migrated further up the Pagsan river creek after their initial appearance at the sandy shores and mouth of the river have now acquired blotches or parr marks on the sides of the body, stellate pigments on the snout and on the head. There are traces of ctenoid

TEXT FIG. 28. *Chonophorus ocellaris*. From a specimen 15 mm. long.

microscopic scales. There are pigment spots on the dorsal and anal fins the most significant of which in *Chonophorus ocellaris* is the rounded black pigment spot at the base of the first dorsal fin on the membrane and spines of the fourth, fifth, and sixth spines.

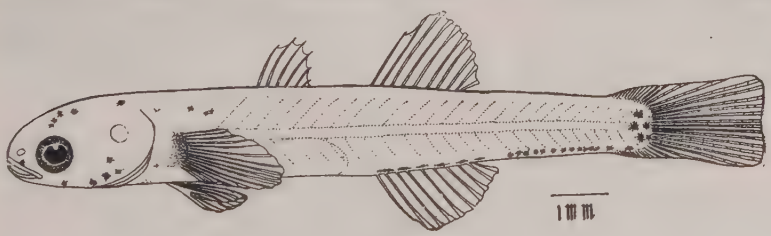
Specimens 16–20 millimeters long.—The goby fry when still a few kilometers from the mouth of the river in their migration up stream after three to four weeks have grown bulky, the body proportions having changed a great deal; the fins, narrow vertical blotches and the grouped dark pigments of the ctenoid scales on each side of the body are now very distinct, so with the ocelie pigmentation on the first dorsal fin, and striations on the membranes of dorsal and anal fins are very distinct.



TEXT FIG. 29. *Chonophorus ocellaris.* From a specimen 20 mm. long.

SICYOPTERUS sp. Goby fry (ipon). Text fig. 30.

Specimen 12 millimeters long.—The body is low, elongate, slightly compressed; height 7 in length; the obtuse convex head about 4.5 in body length; diameter of eye almost 4 in length of head; mouth terminal slightly oblique; snout obtuse to convex; maxillae extending beneath anterior third of eye which is lateral. Opercle with branchiostegals. Dorsals separate VI, I–8; anal I, 8; caudal of 18 rays truncate. Specimen is naked and transparent with traces of notochord and myomeres. Pigments of stellate chromatophores are scanty on the head,



TEXT FIG. 30. *Sicyopterus* sp. From a specimen 12 mm. long.

ventral base of anal fin, ventral side of peduncle and base of caudal peduncle. The species of *Sicyopterus* are small dull-colored fishes found in tide pools, rocky, shallow, coastal waters, and river mouths. They are sources of goby fry in northern Luzon.

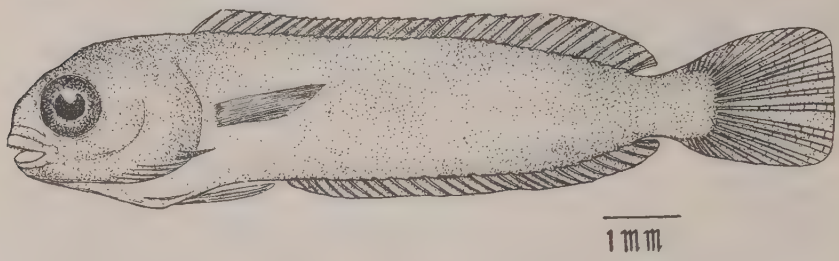
Numerous specimens were collected from a tidal stream at Libong, Bacarra, Ilocos Norte Province, on April 29, 1949.

BLENNIDÆ

SALARIAS sp. Locust fish (dodon). Text figs. 31 and 32.

Specimen 8.75 millimeters long.—Naked body is slender, elongate and laterally compressed; depth 4.66 in standard length. Head is 3.5 in length; mouth transverse with conical teeth; angle of maxillary beneath anterior diameter of eye which is 3.25 in head; snout shorter than diameter of eye. Opercles have spines on lower edge above the branchiostegals. Soft

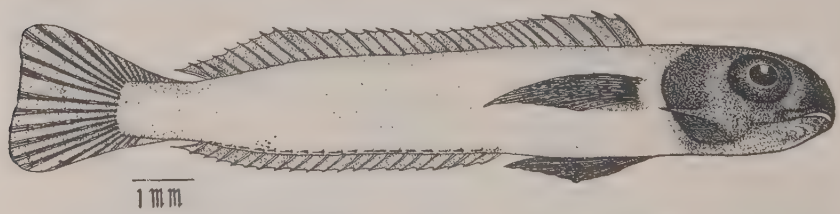
dorsal starts above edge of opercle, continues with 26 soft rays connected with a narrow membrane. Anal also of narrow membrane of 24 soft rays. Caudal, truncate with 16 rays. Pec-



TEXT FIG. 31. *Salarias* sp. From a specimen 8.75 mm. long.

toral fin short not reaching beyond level of eleventh dorsal rays.

In formalin, specimens are creamy white on the sides of the body with dark pigment spots on the head.



TEXT FIG. 32. *Salarias* sp. From a specimen 11 mm. long.

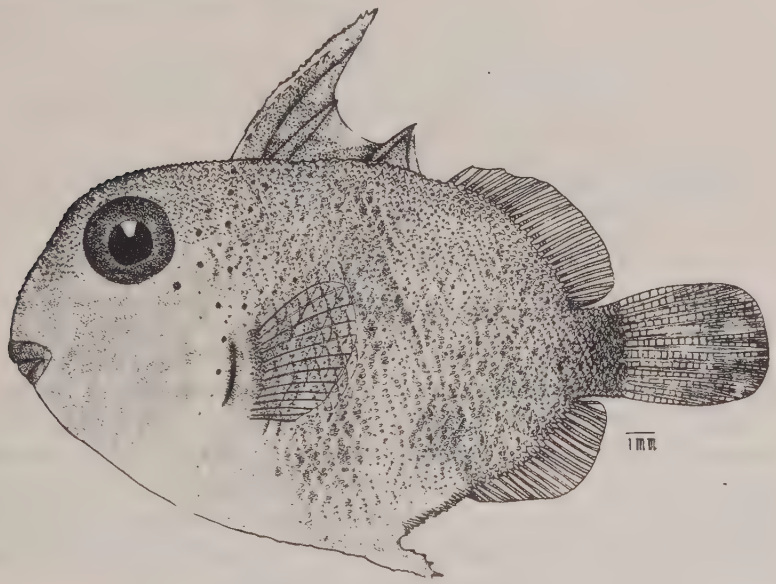
A few specimens, 8.75 to 11 millimeters long, were collected at the Dagat-dagatan Salt Water Fish Farm in 1948.

BALISTIDÆ

BALISTES sp. Trigger fish (papakol). Text fig. 33.

Specimen 24 millimeters long.—The body is oblong, compressed; depth 1.5 in standard length; head short and deep, convex; mouth small and terminal lips thick; eye high up, dorsolateral diameter 2.33 in head. One gill slit is anterior of the pectoral fin. Opercles covered the demarcation of which is noted by the mark of the gill slit. Dorsal fin III, 24; anal 21. Origin of first spinous dorsal is anterior to the base of the pectoral; second spine is very close to the first, being one half as long; third spine is shorter than the second and are far apart but connected with thin membrane. The soft dorsal is low, ends slightly rounded. The anal is similar to the second dorsal; caudal peduncle is twice as long as broad. The caudal fin of 12 rays is subtruncate when spread. The ventral spine is short and broad. Pectoral of 13 rays is small not reaching the

midlateral portion of the body. Scales on the head and sides of the body up to the base of the caudal fin are covered with small, rough, placoid scales.



TEXT FIG. 33. *Balistes* sp.

The color of the specimen in alcohol is brownish yellow with dark pigment spots evenly distributed on the sides of the body, on the spines and membranes of the first dorsal fin.

One specimen was collected at the Dagat-dagataan Salt Water Experimental Farm in June, 1946.

TETRAODONTIDÆ

SPHEROIDES sp. Puffer (bote). Text fig. 34.

Specimen 6.5 millimeters long.—The larval puffer is shaped

TEXT FIG. 34. *Spheroides* sp. From a specimen 6.5 mm. long.

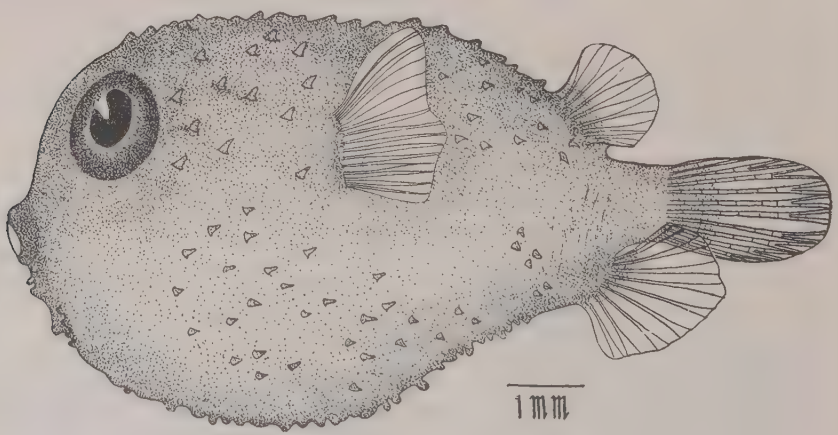
like a bowling pin, with the short caudal peduncle as a neck. The single dorsal with 7 rays and anal fin with 6 rays are near the truncate caudal which has 10 principal rays. The base of the arched pectoral is the middle portion of the body. The fish is pigmented with dot chromatophores on the lateral and dorsal portions of the body except the ventral portion of the head abdomen anterior to the anal fin where it is denuded with such spots.

Several specimens, 6 to 10 millimeters long, were collected from the tidal creek of Pugus, Cabugao, Ilocos Sur Province, on April 19, 1949.

DIODONTIDÆ

DIODON BLEEKERI Gunther. Puffer (boteteng laot). Text fig. 35.

Specimen 10 millimeters long.—The young fish is oblong in shape with a tubular mouth; eye high up in the head. Beginnings of spinelike structures are sparsely distributed on all over the body. The dorsal with 7 soft rays and the anal of 10 rays are nearer the rounded caudal fin of 10 rays. Caudal peduncle as long as narrow. The base of the pectoral fin is at the middorsolateral portion of the body.



TEXT FIG. 35. *Diodon bleekeri.* From a specimen 10 mm. long.

This single specimen is greyish to black and was collected from the tidal stream at Pugus, Cabugao, Ilocos Sur Province, on May 5, 1949.

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FIG. 1. *Elops hawaiensis.* From a specimen 18 mm. long.
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4 and 5. *Aplocheilus luzonensis.* From specimens 5 to 6 mm. long.
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27, 28 and 29. *Chonophorus ocellaris.* From specimens 10 to 20 mm. long.
FIG. 30. *Sicyopterus* sp. From a specimen 12 mm. long.
FIGS. 31 and 32. *Salarias* sp. From specimens 8.75 to 11 mm. long.
FIG. 33. *Balistes* sp. From a specimen 24 mm. long.
34. *Spheroides* sp. From a specimen 6.5 mm. long.
35. *Diodon bleekeri.* From a specimen 10 mm. long.

A GUIDE TO THE RECOGNITION OF FISHES CAUGHT WITH THE USE OF EXPLOSIVES [1]

By CONSTANCIO Y. MADERAZO
Fish Culturist, Bureau of Fisheries, Manila

The necessity of curbing the depredations by unscrupulous fishermen upon the fishery resources of our country through the illegal use of explosives in obtaining fish for the markets is a primary objective of the Bureau of Fisheries in its policy of developing and conserving the aquatic resources. Up to a few months ago, the apprehension of fishermen fishing with explosives has been a "catch-as-catch-can" proposition, but recently the Bureau of Fisheries has been prosecuting fishermen for illegal fishing on the basis of laboratory examination reports on fish collected from the fishing boats as they arrive at the various fish landings. To gain the cooperation of other law enforcing agencies in this important activity by strengthening their arguing points in the courts, the Bureau of Fisheries has prepared this guide to the determination of fish caught with the aid of explosives.

Fishes are caught with explosives through the detonation of a tin can filled with explosive powder which is usually obtained from unexploded bombs, artillery shells, torpedoes, or other sources. The can is fitted with a blasting cap ignited by a short fuse timed to explode some seconds after it is lighted with a match. The fish stunned or killed by the resulting concussion may then be taken by simply diving and gathering them in baskets. Fishes inhabiting shallow coral reefs and banks such as caesios, sea basses, snappers and surgeon fishes are the usual catch, but even pelagic species are attacked in open waters with great wastage of the fish that sink to the bottom beyond diving range.

The Bureau of Fisheries bases its laboratory determination of fishes caught with the aid of explosives mainly upon the following points:

A. External manifestations:

1. Fishes near enough to the blast center suffer wounds and mutilations of various parts of the body such as the loss of scales, the breaking or

[1] This paper was presented by the Philippine Delegation before the second meeting of the Indo-Pacific Fisheries Council held at Cronulla, N.S.W., Australia, April 17–28, 1950.

tearing off of fins, tails, eyes, and lower jaws. Fishes with bodies that are deeper than long may have their abdominal regions literally blown away.

2. Effusions of blood, visible as red splotches under the skin of the fin bases and of the nape, chin, or cheeks.

3. In small and translucent fishes, effusions of blood may be noted through the skin and flesh in the region of the vertebral column and the abdominal cavity.

4. Portions of the viscera may be noted protruding from the vent.

5. The body freely bends sidewise and when pulled lengthwise has a distinct feeling of being loose. This is due to the breakage or loosening of the vertebrae in the spinal column. Fresh fish caught by other means have the stiffness or rigor-mortis.

B. Internal manifestations:

1. Fishes near the vicinity of the blast center usually have the contents of the abdominal cavity crushed, out of position, and mixed with blood.

2. Dislocations or fractures of the vertebrae in the abdominal and/or the caudal region are usually encountered.

3. If bone fractures are present, it will be noted that the broken ends or edges cause the tearing of adjacent tissues and blood vessels, manifested by blood clots and dark-red discolorations of the fish.

4. Even without fractures in the vertebral column, the spinal blood vessels below the vertebrae rupture and cause hemorrhages of varying degree along that region.

5. The swim bladder, if present, is almost always ruptured and blood clots in its lumen may be found.

6. The rupture of the blood vessels of the internal organs causes the formation of blood clots in the abdominal cavity or else a bloody discharge may be noted upon opening the abdomen.

7. Internal organs like the liver and the gonads of spawning fishes may be crushed by the concussion.

8. If the fish are still fresh with the intestinal tract still firm and undamaged by decomposition especially those living on a diet of hard foods, like crabs and mollusks (sea bass and snappers for example), the hard parts of their food may cause the laceration, rupture, and discharge of the contents of the stomach into the abdominal cavity.

C. Other manifestations:

It has been shown to a certain extent in the microscopic studies by Medina (1949) that the chromatophores located on the meninges of the brain change from their usual round, and/or more or less regular stellated shapes to irregular astral forms. This change is easily shown in flat mounts of the brain membrane of a freshly dynamited fish.

Fish should be examined for external manifestations as soon as possible.

In the internal examinations, fish should preferably be hardened first by having them soaked overnight in ten per cent formalin or 70 per cent alcohol so as to allow all liquid blood to coagulate. After the hardening process, the fish should be split along the back from the tail to the skull passing the knife

close to the vertebral column. Thus, an examination of the vertebral column, the ribs, and surrounding areas may be easily made. In exposing the abdominal cavity, a pair of strong scissors should be used and a cut carefully made along the belly and through the throat until one flank covering the abdomen is removed. In this way the arrangement of the internal organs is not disturbed, making the examination of their condition easier.

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OUTLOOK FOR INDUSTRIALIZATION OF THE PHILIPPINE FISHERIES [1]

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During the past fifty years remarkable progress has marked the development of the fishing industry and the half-century can be roughly subdivided into three phases that describe this activity. From 1900 to 1918 the fishing industry was largely in the hands of the Philippine citizens themselves. It was a small and unimportant segment of the overall economy and since the population of the nation was also small at that time, the daily needs of the people were easily met. The techniques employed were crude and were typical of those of southeast Asia generally, although the ingenuity of the average Filipino fishermen had adapted these processes to their particular situation.

Following the first world war, the fishing industry witnessed the gradual infiltration of Japanese interests. These aliens, by hard work and careful management, were able to monopolize a large segment of the industry, particularly the supply of fish to the larger city markets throughout the islands. They introduced a few innovations, very few of which have proved of lasting benefit. But at the beginning of the second world war there is no doubt that these were the dominant factors in the fishing industry in many places.

Following independence in 1946, until the present, a third phase of the fishing industry and the pattern for the immediate future has unfolded. Under the guidance of the Bureau of Fisheries, which was created in 1947, and with the assistance of the American fishery mission of the U. S. Fish and Wildlife Service, the industry has again fallen into the hands of the Filipinos. It has been, to a considerable extent, modernized by the introduction of power to take the place of sail and by experiments with innovations of the existing techniques for cap-

[1] This paper was presented by the Philippine Delegation before the second meeting of the Indo-Pacific Fisheries Council held at Cronulla, N.S.W., Australia, April 17–28, 1950.

turing fish. The Philippine Bureau of Fisheries, by means of its own exploratory fishing fleet, and the Philippine Fishery Rehabilitation Program have conducted extensive surveys throughout the Philippines for the purpose of ascertaining the potential production that might be obtained from Philippine waters.

These surveys have revealed hitherto unsuspected facts concerning the future of the Philippine fishery economy. It has begun to be realized that the fisheries of the Philippines are not overly productive insofar as their fish supply is concerned. In common with many of the tropical countries, the Philippines possesses a wide variety but a limited supply of fishes. It is becoming more and more apparent that if the average Filipino continues to depend upon fish for his animal protein food this natural resource will have to receive the utmost attention from the government to assure its continuation as an asset to the general economy.

There are, however, certain encouraging features that lend themselves to industrialization of a highly specialized kind. The only relatively unexploited segment of the fisheries of the Philippines is tuna. Data collected by the two organizations interested in the fisheries indicate that raw material for canning tuna can be had in parts of the Islands at a price approximately one half of that being paid by the canneries in the great tuna canning centers of North America. This, coupled with a reasonably low-priced labor supply, seems to indicate that there is a possibility of industrializing this segment of the fishing industry for purposes of export. Many problems remain, however, to be solved in this connection, the foremost of which is an adequate supply of tin containers and an organization with sufficient capital to build the type of vessel necessary and in sufficient numbers to assure a steady supply of fish to the processing plant. Also, due to the distance to the markets, this industry would demand an organization possessing considerable working capital. The present demand for tuna in cans, however, is so great that it is considered little difficulty will be experienced in eventually disposing of the pack.

Two other quality products have been developed from tuna. One of these is tuna ham. The fish is treated in a similar way to bacon with a mixture of salt and saltpeter in the right proportion, and then smoked. Prepared according to recipes tested at the laboratory, this product proved to be a gourmet's delight. The other product, the tuna paste, is prepared from

the fish fillet treated in the same manner as the tuna ham. The treated fillet is ground. The resulting ground product is mixed with oil in the right proportion and packed in cans. The preparation is good material for hors d' œuvre and is in reality a high-class bagoong which would find a ready market in many Philippine homes. These two products added to canning could make an industry worth from 4 to 5 million pesos annually and it would be all new wealth. An investment of 2 to 3 million would be needed to develop this business but if present conditions continue it would be amortized in 2 to 3 years. The possibilities for expansion are also good. With plants for processing located in strategic places, exploitation of the stocks of tuna would not need to be confined to Philippine waters but could go on far out in the South Pacific.

No other segment of the industry, however, seems to offer these possibilities. On the other hand, some opportunities have been found for specialty products. The technologists of the Philippine Bureau of Fisheries and of the Philippine Fishery Rehabilitation Program have developed some unique items, any or all of which could be utilized for industrial exploitation.

Years before the second world war the Division of Fisheries had developed a method of cultivating oysters. This method was found very adaptable to Philippine conditions and has found general acceptance among oyster growers around Manila Bay. The local species of oysters grow to marketable size in six months, and in some places, like Pangasinan Province, the time is shorter by two months. At this stage the oyster is just the right size for packing as a cove oyster for the American trade. This consists of oyster meat packed in brine. Technologists of the Philippine Fishery Program have also found a very suitable pack for the Philippine oyster in the form of a smoked product. This consists of cooking the oyster meat and smoking it for some time. The smoked oyster is then packed in oil. This product meets the approval of all who have tasted it and is suitable as a canape.

There are fishing centers in the Philippines where anchovies (dilis) seem to be ever abundant. The most common commercial method of preserving this fish is by salting it in the form of fish paste (bagoong). A quality product has been made from this fish following a formula for canning developed at the technological laboratory of the Philippine Fishery Program. This item has a wide variety of uses both as a specialty and as a staple. Dilis is recognized as one of the most nutritious

fish in the Philippines and proposals have been made to can this species for local consumption to supplement the imported canned sardines.

In addition to the products listed above, many others are under consideration by the Philippine Bureau of Fisheries at the present time. One of their projects is a ration of rice and fish for the eventual use of the Philippine Armed Forces. Experiments are continuing on other unique Philippine products which, if they prove feasible, would win a ready market within the nation but would have limited appeal to the export market.

Both the Philippine Bureau of Fisheries and the American fishery mission have exerted considerable effort in the improvement of many processing procedures now being used in the Philippines. Thus, they have developed an improved method for salt production, which gives a pure product and increased yield and will in time prove a boon to both the salt industry and fish processors who use the product. Both organizations have also studied the techniques involved in the production of bagoong and patis and the outcome seems very promising for speeding this process and thus rendering each cheaper for the customer.

Both the Philippine Bureau of Fisheries and the American fishery mission have looked into the matter of industrial packing of sardines and mackerels and other types of fish. The fact remains, however, that the demand for fresh fish in the Philippines is so great and the price of most fresh fish concurrently so high, that it is considered impossible at this time to profitably can either sardines, mackerels or bangos. For purposes of comparison, the current price of sardines in California for canning and other processing is ₱65.00 per ton. The same fish in the Philippines varies in price at from ₱180 to ₱300 per ton. Mackerel and bangos fall in the same price range categories. The loss from trimmings plus the labor involved in packing added to the price of containers and condiments, precludes industrialization of these species either for local consumption or for export.

The Bureau of Fisheries is concerned with the welfare of the average Filipino citizen and has directed many of its technological efforts toward solving some of the important problems that arise in this connection. One of these problems arises from the fact that during an average year, in most localities, there are times when fish are relatively scarce and there are other times when they are comparatively abundant. The Bureau is concerned about taking care of those fish that can

be taken during the period of abundance and has thus devoted much of its time toward developing techniques that can be used in the average Filipino home. The Bureau is ready, however, to render assistance to anyone interested in any of these industrial processes.

While on the whole these cannot be said to be startling developments of an industrial nature in the fishing industry, still the progress during the past four years has been steady and all developments have been carefully considered and assayed judiciously. Perhaps the most significant aspect of this phase of the Philippine fisheries has been that the government officials concerned have become aware of the needs of the fishing industry and are applying the best of their talents to the solution of immediate problems and eventual expansion where such can be shown to be worthwhile and profitable.

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A BIBLIOGRAPHY OF PHILIPPINE FISHES AND FISHERIES [1]

By GUILLERMO J. BLANCO and HERACLIO R. MONTALBAN
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Literature on Philippine fisheries is extensive and scattered. It covers various fields of fisheries science, such as technology, biology, planktology, algology, ichthyology, carcinology, conchology, and oceanography which have been investigated and studied by Filipino research workers and foreign scientists. The scientific papers prepared as a result of such investigations and studies were, therefore, published in this country and abroad. With the creation of the Philippine Bureau of Fisheries, the implementation of the Philippine Fishery Program under the United States Fish and Wildlife Service, the organization of the Fisheries Society of the Philippines, and the membership of the Philippine Republic in the Indo-Pacific Fisheries Council, there has developed a keen interest among our technical men to engage in fisheries research.

This bibliography will serve as a ready reference to these workers and to others who may be interested to have access to such publications. Although most of the publications in our private collections and in Government libraries have been lost as a consequence of World War II, we may recover some if not all of them through the use of this bibliography which contains references published as far back as 1865.

[1] Manuscript submitted to the 3rd Meeting, Indo-Pacific Fisheries Council at Madras, India, February 1–16, 1951.

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THE THERMAL STRUCTURE OF THE SURFACE WATERS OFF WESTERN PHILIPPINES BASED ON BT OBSERVATIONS

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EIGHT TEXT FIGURES

Within the lighted portion of the water column in Philippine waters there are two distinct layers easily distinguishable by their thermal structure. Superimposed upon the discontinuity layer or the main thermocline is the mixed or isothermal layer of uniformly high temperature. Owing to phytoplankton activity, the isothermal layer is generally deficient in the chemical nutrients known to regulate and limit plant growth. The thermocline below militates against the vertical movements of the richer waters beneath it, as a consequence of which there is no active replenishment of the impoverished waters within the isothermal layer.

While it is highly desirable to study the thermal structure of both layers in order to acquire a more thorough understanding of the mechanisms controlling nutrient exchange, the BT (bathythermograph) tows did not penetrate deep enough to reach the lower boundary of the main thermocline. The maximum BT penetration never exceeded 150 meters. Below this depth there were still evident significant temperature gradients as shown by the vertical temperature distribution curves based on the hydrographic data.

To conform with the standard units adopted by the Indo-Pacific Fisheries Council with which the Philippines is affiliated, the BT measurements of temperature and depth are expressed in the metric system. The conversion facilitated the scaling of values corresponding to the standard depths adopted in the reduction of the hydrographic data, thus permitting comparison between the two types of data.

Except for a few stations occupied during the first part of the survey, the BT observations were made at points approximately midway between pairs of successive stations.

The data used in this study were collected by the *Spencer F. Baird* of the United States Fish and Wildlife Service in July and August, 1949 at the height of the southwest monsoon period. The survey was completed in a single cruise of 24 days.

Though the data at hand are not by any means complete as to provide a closer coverage of the area under study and comprehensive enough as to present fully the average condition of temperature during the southwest monsoon period, the results yield valuable information that permits the drawing of general conclusions.

SOURCES OF ERROR

Two bathythermographs were used, the first having been lost overboard at BT–861 when rough seas were encountered during the first leg of the survey. The performance of the two instruments was satisfactory throughout except in one instance at BT–836 where the lost BT showed an apparent shift in its "zero point". While a shift in the zero point does not affect the shape of any given trace, wide deviations from the reversing thermometer temperature reading should amply warn of the necessity for adjustment or repair of the instrument. Owing to the fact that a different calibration grid was used in scaling values from the traces recorded by one of the two bathythermographs, there may be a systematic error in the absolute values of the temperature data. Since, however, all the BT temperatures were referred to the hydrographic data, such error can be expected to be of little significance. Due to the limitations in the accuracy of the instrument and the conversion of values from one unit to another, the temperature values may deviate as much as 0.2° C. and the depths not greater than five meters from their true values. These errors, however, are within the accuracy required.

REDUCTION PROCEDURE

The conversion of depth in feet into the metric unit was effected by using a transparent sheet upon which the lateral grid lines were etched to correspond to depths expressed in meters. Temperature values scaled to the nearest 0.1° F. were converted to ° C. and later corrected for the difference between the BT reading and the mean of the two reversing thermometer surface readings taken from the nearest pair of consecutive hydrographic stations. If both types of observations were made in the same station, the correction was based on only one reading. In either case this correction was applied to all the BT readings corresponding to the other standard depths. The converted values appear under each station in Table 1.

TABLE 1.—*Corrected temperatures in °C corresponding to standard depths expressed in meters*

Depth	BT—820	—822	—824	—826	—829	—833	—836	—843	—846
0	29.4	29.4	29.3	29.3	29.5	30.0	29.1	29.4	29.1
25	29.2	29.3	29.3	29.2	29.5	29.9	29.1	29.6	29.1
50	27.8	28.7	29.3	28.9	29.1	29.2	28.8	28.5	27.0
75	24.0	22.2	23.8	21.6	25.4	22.9	------	24.5	24.0
100	24.0	19.5	------	19.5	21.1	20.5	------	21.3	------
125	------	16.6	------	------	------	------	------	------	------

	—848	—850	—855	—861	—863	—865	—867	—869	—871
0	29.1	28.8	28.5	29.3	29.7	29.5	29.1	29.4	29.6
25	29.1	28.8	28.5	29.2	29.6	28.3	28.7	29.1	29.3
50	28.6	28.7	28.1	29.0	29.5	28.3	28.5	28.9	27.0
75	23.9	------	26.7	26.9	26.9	26.9	25.4	22.9	23.6
100	------	------	24.6	25.0	23.6	24.5	23.2	20.4	------
125	------	------	20.7	20.9	------	21.2	------	------	------

	—873	—876	—878	—880	—833	—885	—890	—892	—894
0	29.4	29.4	29.5	29.3	29.3	29.3	29.1	29.5	29.7
25	29.1	29.2	29.3	29.0	29.1	28.8	28.5	28.7	29.4
50	25.4	28.4	29.2	28.0	27.5	28.2	27.1	28.4	29.2
75	------	23.8	------	25.6	24.3	25.7	24.7	25.8	24.8
100	------	20.6	------	------	22.7	23.5	22.5	22.3	22.3
125	------	------	------	------	------	------	------	20.9	20.7

	—896	—899	—901	—903	—906	—908	—910	—913	—915
0	29.3	29.1	28.9	28.9	28.8	28.7	29.9	29.2	29.1
25	29.2	28.0	28.6	27.8	26.6	28.9	28.9	28.2	29.0
50	26.6	25.1	24.2	25.8	25.9	27.3	26.4	27.4	27.3
75	23.5	21.6	21.9	20.9	23.6	24.7	23.0	25.9	25.3
100	21.0	19.8	19.5	18.6	19.6	20.1	21.0	24.6	22.5
125	19.3	------	------	------	17.8	------	19.4	------	------

	—917	—920	—922	—924	—927	—929
0	28.9	29.1	29.5	29.7	29.7	29.9
25	28.0	28.8	27.9	28.6	29.4	29.3
50	27.4	27.9	27.3	27.2	28.3	28.9
75	25.7	26.9	25.8	25.6	25.0	27.2
100	23.4	25.4	22.4	22.4	22.4	24.1
125	21.4	------	19.8	------	------	22.4

Where sharp inflections in the curve occurred above the first significant temperature gradient, they were disregarded if it was apparent that they were due not to a special feature of the water but to the unavoidable jagging of the instrument caused by the uneven tension of the BT wire at any one time.

Owing to the gradual transition between the isothermal layer and the thermocline as indicated by a number of the traces, the difficulty of ascertaining the depth of the isothermal layer necessitated the establishment of an arbitrary measure of temperature gradient. Thus for our purpose a gradient less than

1° F./25 feet (about 1° C./15 meters) did not constitute a thermocline. On this basis the total temperature drop within the isothermal layer did not exceed 2° C. in all cases. That depth below which the first significant gradient occurred was accepted as the depth of the isothermal layer. Layer depth values are entered in Table 2.

TABLE 2.—*Layer depth temperature*

Station No.	Layer depth		Station No.	Layer depth	
	C. meters			*C. meters*	
BT—820	29.0	36	—880	29.0	40
—822	28.9	49	—883	29.0	46
—824	29.2	52	—885	28.8	43
—826	29.0	49	—890	28.5	40
—829	29.4	49	—892	28.3	52
—833	29.9	47	—894	29.1	53
—836	29.6	55	—986	28.9	43
—843	29.3	38	—899	28.4	37
—846	29.0	34	—901	28.7	21
—848	29.4	45	—903	28.9	15
—850	29.0	47	—906	28.6	31
—855	28.9	38	—908	27.6	46
—861	29.8	43	—910	28.1	30
—863	29.5	51	—913	29.2	13
—865	29.3	52	—915	29.0	27
—867	27.7	55	—917	26.8	50
—869	28.8	54	—920		
—871	29.2	40	—922	26.7	64
—873	28.5	34	—924	29.0	57
—876	28.8	44	—927	28.5	55
—878	29.4	54	—929	28.6	57

STATION PLAN

Fig. 1 shows a layout of the carefully spaced network of BT and hydrographic stations occupied during the survey. Numerals represent station numbers. Where no BT station is shown between any two adjacent hydrographic stations occupied in succession, BT observations were taken when the boat stopped to make hydrographic measurements.

TEMPERATURES

The spacing of isotherms in the distribution chart for temperature at the surface was made at an interval of 0.2° C. as against 0.5° C. at 50 meters. This is to bring out by comparison the interesting feature shown by the strong horizontal temperature gradients at 50 meters over Stewart Bank located approximately in the western center of the 5° quadrangle west of northern Luzon.

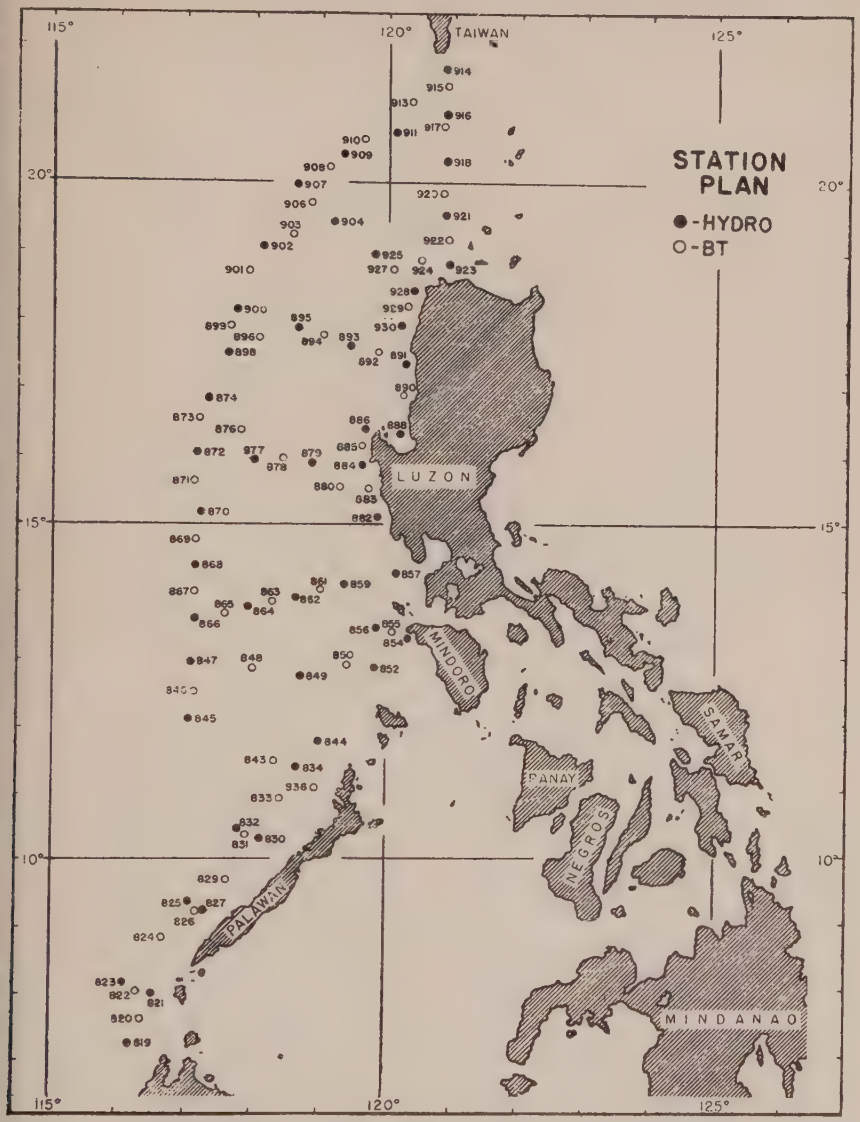


FIG. 1. Lay-out of stations occupied during the cruise of the *S. F. Baird*, July-August, 1949

Figs. 2 and 3 present the horizontal distributions of temperature at the surface and at a depth of 50 meters.

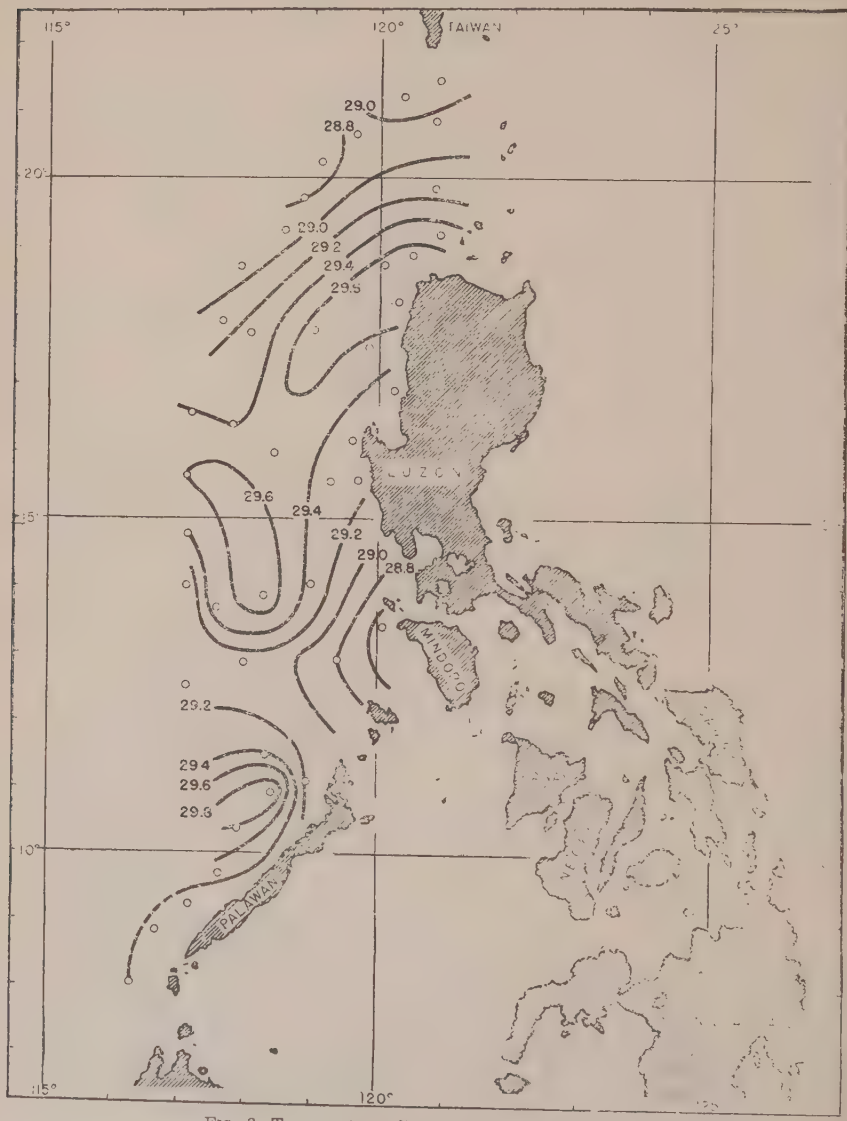


FIG. 2. Temperature distribution at the surface.

Surface.—Temperatures are generally lower in the northern than in the southern part of the area, the difference between the maximum and minimum values exceeding 1.0° C. In the southern part close to the shore the temperature increases from east to west but shows a reverse trend in the area to the north off northwestern Luzon.

Two patches of water having a temperature higher than 29.6 C. make up the warm region which appears west of

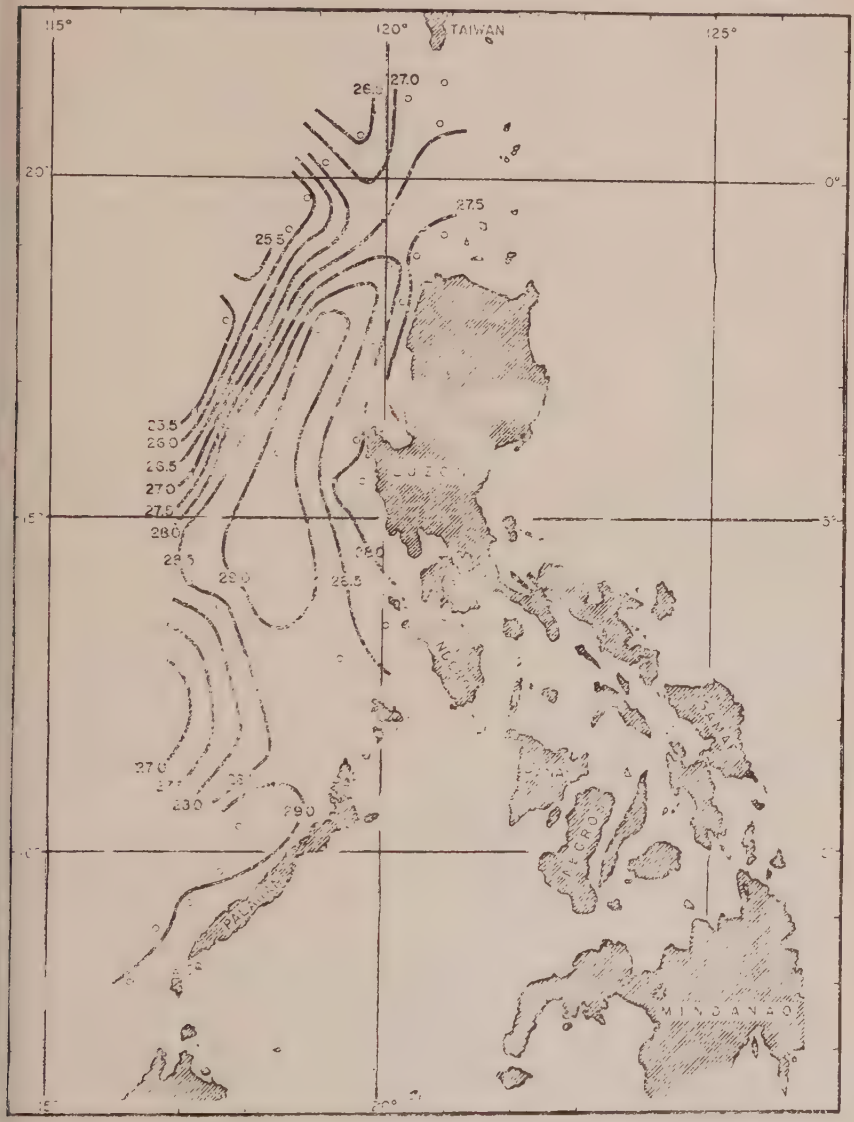


FIG. 3 Temperature distribution at 50 meters.

Luzon. This warm water has been found by Leipper and Wood (1947) to migrate from north to south during the northeast and in the opposite direction during the southwest monsoon period. Due to its large extent and its apparent displacement further south than when found by these investigators,

it seems likely that this warm water must have reached the limit of its southern migration at time of survey.

Another region of warm water much less in extent but of higher temperature appears off northwestern Palawan. Presumably this is a part of the South China Sea water that has broken away from the parent stream and found its way through the narrow trough separating Palawan from the extensive shallow reefs to the west. Upon hitting the shallow area at the northern tip of Palawan, the water departs from its normal course to form what appears to be a tight eddy. This pattern of flow based on the tonguelike distribution of temperature may not be confirmed by the actual streamlines owing to the wider fluctuations in salinity as shown by the hydrographic data.

Fifty meters.—At this depth the two warm patches found at the surface close to each other have coalesced to form a band of water tapering off to the northeast. Its broad base extends as far south as 13° 30′ N. latitude. The other end is seen to extend as far north as 18° N. latitude.

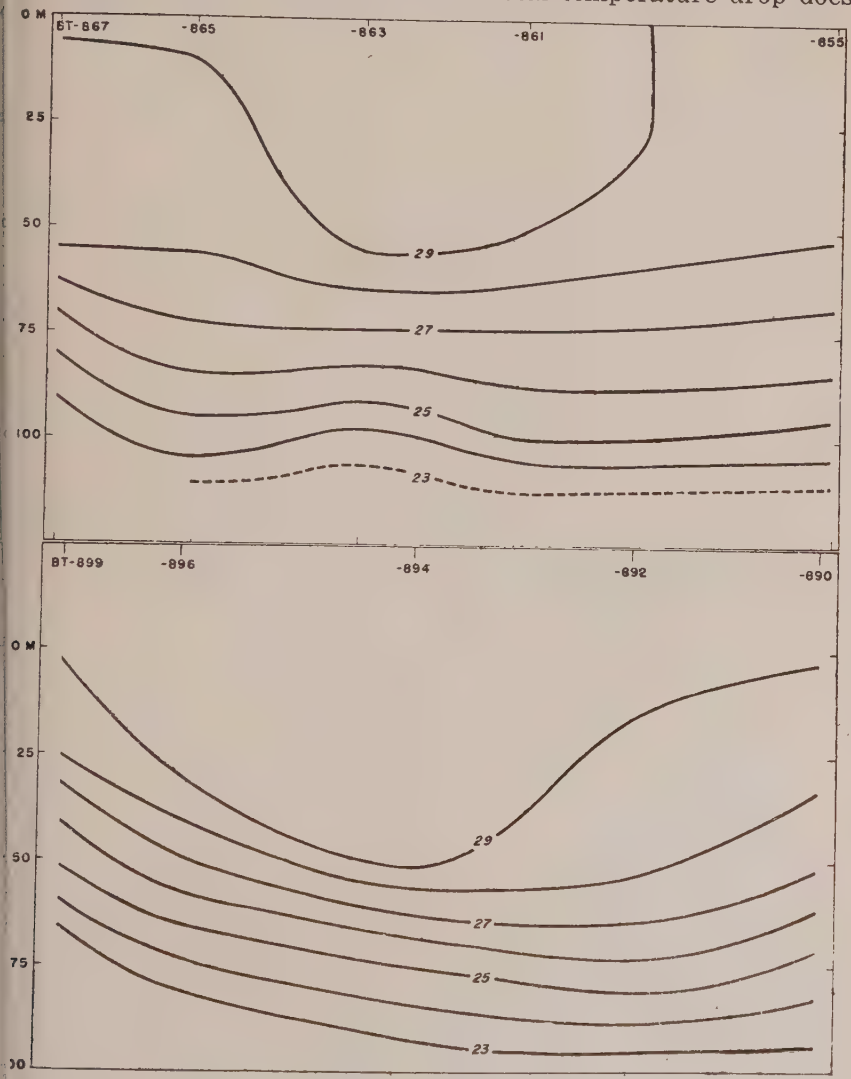
A special feature of the temperature distribution at this depth is the packing of the isotherms over and in the vicinity of Stewart Bank referred to previously. These marked horizontal temperature gradients reveal the possible presence of processes taking place that may account for the highly productive fisheries reported by fishermen in that area. That the presence of the cold water there is not a temporary feature is corroborated by the Japanese data collected during the same period in 1937.

Another noteworthy feature of the temperature distribution at this depth is the appearance of a tongue of warm water extending northeastward from the region of warm water.

ISOTHERMAL LAYER

Figs. 4, 5, and 6 are profiles presenting the extent of the isothermal layer. The first profile runs along the line of stations from BT–855 to BT–867 cutting across the base of the band of warm water enclosed by the 29°-isotherm shown in fig. 3. The second profile starts from BT–890 directly north of Lingayen Gulf and extends northwestward in the direction of Stewart Bank. The position of the profile in fig. 6 was chosen to conform with the apparent axial position of the 50-meter isobath, which is shown in fig. 7 to run from BT–822 west of Balabac Strait to BT–917 in the Bashi Channel south of Formosa.

These profiles show the 29°-isotherm to define the lateral and vertical boundaries of the isothermal layer everywhere except as shown in fig. 4. On either side of the isothermal layer shown in this figure, there is another layer of water of greater thickness within which the total temperature drop does



FIGS. 4 and 5. Profiles of isotherms in the southern and northern parts of the isothermal layer.

not deviate more than 1° from 28° C. This profile further shows lower temperatures at all depths than in the southern section of the central core of warm water. This may be due

to solar heat being rapidly dispersed downward by more active vertical circulation. The same process probably also explains the disappearance of the 29°-isotherm in the landward part of the section. That the mixing resulting from such circulation does not penetrate deeper than 50 meters is shown by the position of the 28°-isotherm which is only slightly displaced horizontally. The obliquity of the isotherms on both sides of the isothermal layer in the northern section indicates that the horizontally unstable water mass depicted in fig. 3 extends to greater depths.

The crowding of the isotherms on the southern part as shown in fig. 6 indicates the intensity of the thermal stratification

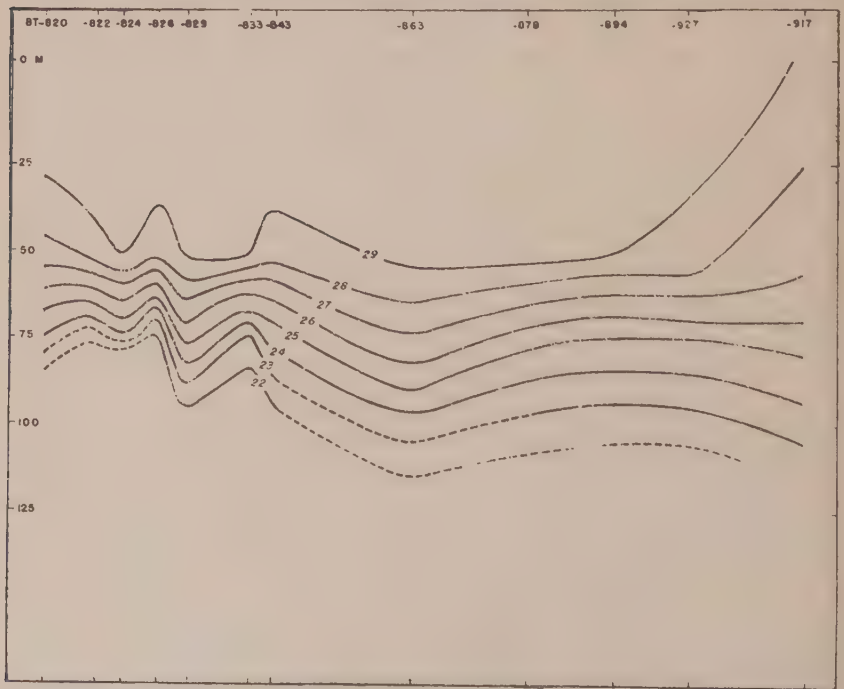


FIG. 6. Profile of isotherms in a longitudinal position near the center of the isothermal layer.

below the shallow isothermal layer there, while their sharp slopes probably represent the combined effects of the tight eddy referred to previously and the unusually rough seas encountered during the first days of the survey. The distortion of scale in representing horizontal and vertical distances in the profile exaggerates the slopes which will appear more gentle under actual sea conditions. Beyond the northern periphery of the small eddy the isotherms rise slowly at first and then slope

rapidly upward as the water reaches the passages north of Luzon.

The series of BT traces presented in fig. 8 show roughly the direction of movement of the isothermal layer and the rate of its transport. Degradation of the gradients follows the

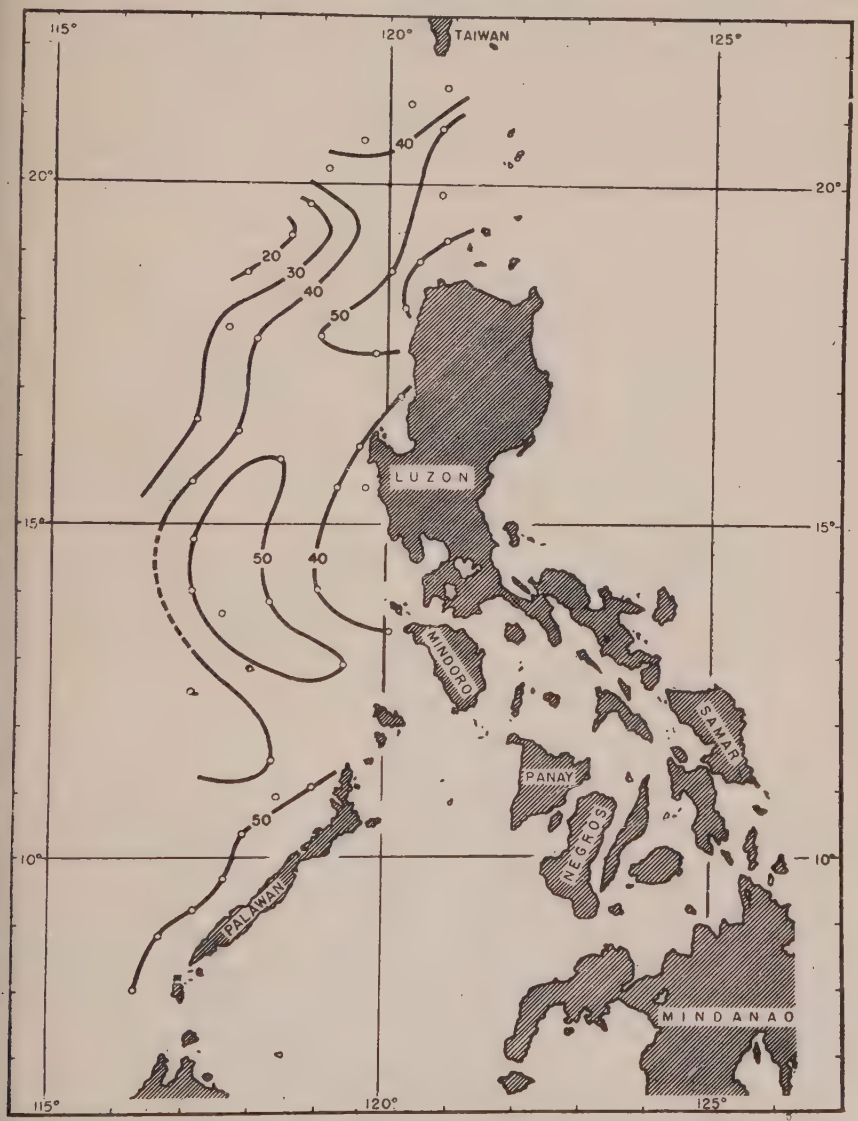


FIG. 7. Layer depth chart.

assumed line of flow. Based on the concept of maximum flow in the direction of maximum degradation, the rate of motion should be greatest toward the north in the direction of the axis of the isothermal layer.

CONCLUSIONS

The full understanding of the mechanism responsible for the transport of water deduced from the degradation of the traces in fig. 8 must await specialized studies. Whatever the mechanism, such transport probably will be destructive to the fishing grounds on the narrow insular shelf to the extent that the freely floating plant and animal life may be carried away from the coastal waters where they maintain the fisheries.

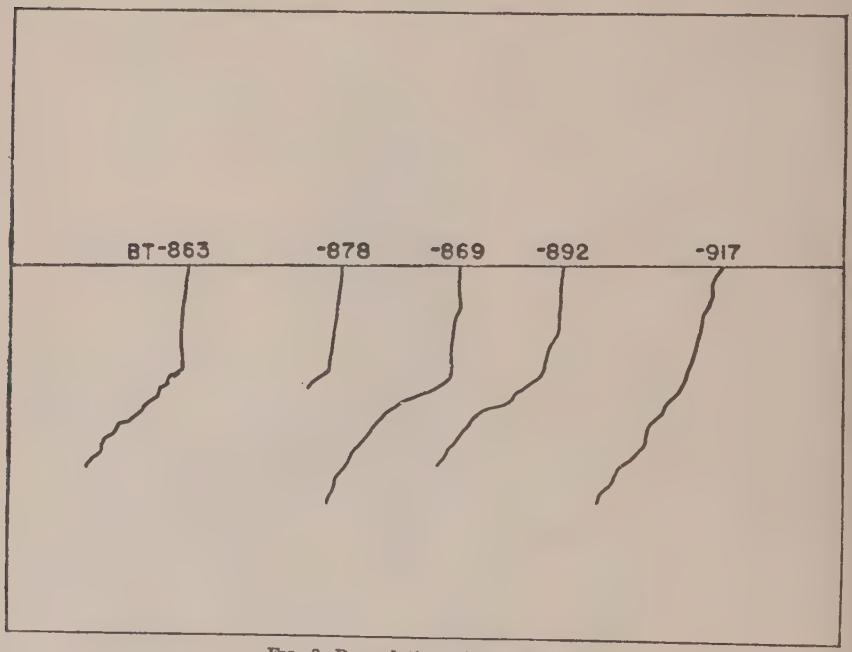


FIG. 8. Degradation of gradients.

The importance of this mechanism seems to have been recognized by the Japanese who investigated the other side of the isothermal layer near Stewart Bank. The promiscuity of distribution of the stations they occupied in that area apparently shows an attempt to analyze the agency responsible for the maintenance of the horizontally unstable water mass shown in figs. 2 and 3.

The banking of cold water against the edge of the isothermal layer near Stewart Bank and the presence of the tongue of warm water off northwestern Luzon (fig. 4) are special features of the temperature distribution that should be of value to tuna long-line operators. Japanese investigations show that such thermal features are indicative of routes of migration of the tuna.

What effects this thermal structure of the isothermal layer and the thermocline have on the biological processes can probably be deduced from a study of the distribution of the chemical and biological data also collected during the cruise. Such aspect was outside the scope of this report and, therefore, no attempt was made to analyze them. However, a few statements may be worthwhile to make at this time. If the temperature gradients within the thermocline are strong, lateral diffusion can be expected to be correspondingly great and if the isotherms sweep upward in a particular region, the return of the plant nutrients removed from the layer of plant activity can easily take place. Due to the persistence of the thermocline throughout the year in Philippine waters especially in offshore areas, the isopycnic transport of nutrients, which has been appreciated for some time, appears to be the only effective mechanism that brings up plant nutrients from below. For the purpose then of assessing the fertility of Philippine waters, stress should be given on the investigation of the large-scale horizontal circulation of our waters, the forces that maintain it, and the biological processes with which it is associated.

Admittedly, the thermal structure of the water presented in this report may represent only one stage in the cycle of oceanographic events. However, its investigation such as was attempted herein may provide a starting point in analyzing the secular changes in its character.

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ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Layout of stations occupied during the cruise of the *S. F. Baird*, July–August, 1949.
2. Temperature distribution at the surface.
3. Temperature distribution at 50 meters.
FIGS. 4 and 5. Profiles of isotherms of the northern and southern parts of the isothermal layer.
6. Profile of isotherms in a longitudinal position near the center of the isothermal layer.
7. Layer depth chart.
8. Degradation of gradients.

OCEANOGRAPHY IN THE PHILIPPINES[1]

By Alfonso R. Sebastian
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Oceanography, as the study of the sea in all its aspects, is the meeting ground of various sciences that deal with the sea. In the special physical, chemical, and biological fields, oceanography is of very recent development in the Philippines. The first scientifically significant study of our waters was made in 1874 and 1875 by the globe-encircling *Challenger* expedition; the latest is that of the *Galathea* in 1951. Up to the intensive survey here of the *Spencer F. Baird* in 1947–49, only three foreign expeditions of similar nature (not including the Japanese-sponsored ones) have visited our shores, namely, the *Planet* in 1912, the *Dana* in 1929, and the *Snellius* in 1929–30. All others have only served in a general way to establish gross features of the ocean bottom and the general distribution of certain physical and chemical properties. Miguel Selga, S. J., former director of the Philippine Weather Bureau, has made a fine chronological compilation of these contributions to the oceanography of the Philippines, starting from Magellan's historic "first sounding" of the Pacific in 1521 up to the beginning of the present century.

Among the most noteworthy expeditions of the sixteenth century that made definite contributions to Philippine hydrographic knowledge, Selga mentions the *Nuestra Señora de Buena Experanza* (1587) which obtained astronomically determined positions for several places of the Islands, particularly the Pratas Shoal and the Babuyan Islands, and that of the *Desire* (1588) under Thomas Fuller, who made detailed observation of heights, soundings, latitudes and distances of certain places like Cape Espiritu Santo, Sibuyan Island, Panay, Negros, and Mindanao. In the seventeenth century Hernando de los Rios Coronel, inventor of the *astrolabe,* sent to Madrid from Manila a map he had drawn of Formosa Island, Luzon, and China, and wrote important sailing directions for the Manila–Nueva España (1605) and Acapulco–Manila (1611) routes.

[1] This paper was submitted as a contribution of the Philippine Delegation to the Third Meeting of the Indo-Pacific Fisheries Council at Madras, India, February, 1951; brought up to date as of August, 1951.

In 1662 a Dominican priest of Manila, Ignacio Muñoz, prepared a book on navigation as well as a series of hydrographic charts which was exaggerated as the best representation ever made at that time of all the oceans that have been navigated. Francisco Ignacio Alzina, S.J., after 30 years of missionary work in the Visayan Islands, left in 1668 a manuscript report containing, among various subjects, a detailed account of the tides and currents of the region. The outstanding expedition of the period was that of the *Cygnet* (1688) in southern Mindanao where William Dampier was the first to describe in the English language the havoc done on the bottoms of ships by the *teredo* of our coasts.

In the eighteenth century two officers, Francisco Diaz Romero and Antonio de Chandia, jointly published a Philippine map in 1727. In 1734 Pedro Murillo Velarde, S.J., published a hydrographic map of the Philippine Islands which became popular and which served for more than a century as the basis for subsequent maps by European geographers. This map showed the reef of rocks on the China Sea where the English ship *Scarborough* struck on September 12, 1748, fourteen years after its publication. This shoal has since been known as the Scarborough Shoal. In 1762 William Nicholson, master of the *Elizabeth* belonging to the British fleet that captured Manila, made a hydrographic map of Manila Bay and Cavite harbor that presented the configuration of the shore line with such exactness and the depths with such accuracy that it can still be used for vessels in entering the bay. The map also gives tidal data and bearings of the dangerous San Nicolas Shoal. In 1789 an expedition under Captain Alejandro Malaspina left Spain on a five-year scientific world cruise to collect botanical and zoological specimens and to study the navigation, meteorology, and hydrography of the various oceans. The corvettes *Atrevida* and *Descubierta* belonging to the expedition reached the Philippines early in 1792 and made astronomical, magnetic, meteorological, hydrographic and gravity observations at several places. Captain Jose Espinosa, one of the officers of the expedition who published an account of events therein, later became the Chief of the Hydrographic Service in the Philippines, upon the recommendation of Governor Aguilar of the Philippines in 1796 in connection with the formation of a Hydrographic Atlas on the occasion of the opening of the port of Manila to foreign ships and the occupation of the Singapore Straits by the British Navy.

At the beginning of the nineteenth century the ship *Santa Lucia* commanded by Riquelme surveyed the Scarborough Shoal, and the ship *Magallanes* did hydrographic work in the Bashi Channel. In 1808 William Dalrymple, navigator turned hydrographer, published several maps, charts, routes, sailing directions, and narratives of voyages over the Pacific. A French chart of the Basilan Strait was drawn by the French pilot Philibert on board the *Rhone* in 1819. In the same year, Mallat published a map of the Sulu Archipelago and a book dealing with Philippine hydrography. The United States Exploring Expedition under Captain Charles Wilkes visited the Philippines in 1841 and 1842 and made some observations on meteorology and hydrography. In 1843 the British ship *Samarang* under Captain Edward Belcher reconnoitered Philippine seas, made several magnetic observations at Manila, Cavite, and Zamboanga, and determined astronomical latitudes and longitudes and magnetic variation and dip at several places. From 1850 to 1873 three English expeditions visited Philippine shores. The *Royalist* under Bate surveyed the western coast of Palawan and adjacent reefs (1850–54), the *Rifflemann* under Reed surveyed the Balabac Strait (1868–69), and the *Nassau* under Chimmo reconnoitered the eastern coast of Palawan and surveyed part of the Sulu Archipelago, obtaining some values of temperature of the deep waters.

In 1874 and 1875 the famous British *Challenger* expedition, perhaps the most comprehensive exploration of the sea in its physical and biological aspects that has ever been attempted by any single agency, called at several Philippine ports during its circumnavigation of the world (1872–76). Special investigations of chemical, physical, and biological conditions were conducted. Soundings and temperature observations were made in the Sulu Sea and deposits were trawled from the bottom in the Visayan region. In addition, magnetic, meteorological and astronomical observations were attempted. In 1879 the *Derrotero del Archipelago Filipino* or the Coast Pilot, based upon the hydrographic survey of Montero, the investigations of Spanish naval officers, the British survey of the Balabac Strait, Palawan and Jolo, and the survey of the island of Isabela de Basilan by the French navy, was published by Camilo de Arana. The work referred mainly to tides and tidal streams, depths, water temperatures, and variations of the compass. In 1881 the United States undertook two important hydro-

graphic investigations related to the oceanography of Philippine waters. The first was for the preparation of new large scale charts of the China Sea; the second, for the accurate and modern redetermination of the latitude and longitude of points to which capes, islets, towns, and lighthouses had been previously referred. The gunboat U. S. S. *Palos* transported the officers and instruments from port to port.

At the turn of the century, from 1907 to 1909, the U. S. Fisheries steamer *Albatross* was actively engaged in securing hydrographic, dredging, and physical records of almost all the seas of the Philippine Islands and adjacent waters. In 1907 the German survey vessel *Planet* made 36 depth determinations from southeast Mindanao to the eastern coast of central Luzon and by a network of soundings in four cross-sections discovered a trough which proved to be the deepest bottom of any ocean in the world, from 8,000 to 9,000 meters in depth. Later, in 1912 the same vessel sounded 32,078 feet about 40 miles off the north coast of Mindanao. In 1927 another German vessel, the cruiser *Emden,* explored the same region using echo-sounding apparatus and correcting for temperature, salinity, and pressure conditions. It made several hundred soundings 46 of which exceeded 10,000 meters, and recorded the deepest part of the world, 10,793 meters or 35,410 feet, 40 miles east of Northern Mindanao. In 1929 the Danish steam vessel, the R. S. S. *Dana,* on an oceanographic voyage around the world stopped at the Philippines and made observations of temperature, salinity, and oxygen content in the south China Sea and in the Sulu Sea. In 1930 the 1,055-ton Dutch steam vessel, H. M. S. *Willebrord Snellius,* while engaged in oceanographic research in the seas of the East Indies, visited the Western Pacific and made several soundings of the Philippine Deep. Records are available of Japanese oceanographic investigations made in and around Philippine waters from 1934 to 1943, involving several observations of temperature, salinity, oxygen, nutrient salts, and pH up to about 1000 meters. It is worthy of note that earlier surveying ships of the Imperial Japanese Navy, particularly the *Manshu,* the *Yamato,* and the *Musashi,* engaged for several years in biological and hydrographic investigations of the southwestern sector of the North Pacific Ocean, and that bottom deposits of the Philippine area are contained in the map prepared of these reports by Hanzawa of the University of Sendai. Various cutters of the U. S. Coast and

Geodetic Survey operated in Philippine waters before the Pacific War, charting our coast and doing various other hydrographic work. Prominent among these were the *Marinduque,* the *Fathometer,* and the *Pathfinder.* The work has been taken over by the various survey ships of the Philippine Bureau of Coast and Geodetic Survey.

In July and August of 1951 the *Galathea,* a 1,630-ton Danish Navy corvette, on a two-year round-the-world deep-sea research expedition (1950–52), made intensive studies of the Philippine Deep. The survey was chiefly biological in nature, although hydrographic and magnetic work was also attempted. Bottom sediments and samples of marine life at the immense depths were hauled to the surface. This is the first time scientific studies with modern methods and equipment have probed down to 35,000 feet below the sea. Among the many scientists on board under Dr. Anton Bruun during its stay in Philippine waters were three Filipino specialists from the Philippine Bureau of Fisheries.

Prior to 1947 no single office in the Philippines was directly responsible for the collection and compilation of physical, chemical, and biological oceanographic data. The Philippine Weather Bureau, through its marine meteorology section, still collects and compiles sea temperature data from reports of commercial vessels, but reports are wholly confined to observations of surface values. This is more or less a continuation of the work done in 1920–31 when Selga compiled about 4,000 observations of sea surface temperatures in the Philippines, collected from the log-books of ocean-going, commercial steamships, U. S. Army-Navy transports, interisland vessels, and cutters of the U. S. Coast and Geodetic Survey. The Philippine Bureau of Coast and Geodetic Survey, which is charged with the duty of surveying the coasts of our Archipelago, sounding its oceans, and charting its bays, also collects at its tidal stations sea water samples and analyses them for salinity, but observations are also limited to the surface waters. At present the Bureau of Fisheries is the only entity of the Philippine Government amply equipped in materials and men for the physical, chemical, and biological study of our seas.

Early in 1947, under the terms of the Philippine Rehabilitation Act of 1946, the U. S. Fish and Wildlife Service, through its Philippine Fishery Program, began an oceanographic investigation of Philippine waters that is said to be the most inten-

sive survey ever attempted in the history of the science. In two years its exploratory fishing and research ship, the *Spencer F. Baird,* a converted diesel electric tug of 800 tons gross with two 950 horsepower engines, explored an area of 810,000 square miles of Philippine seas, occupying no less than 526 oceanographic stations averaging 1,500 meters in depth, some going as deep as 2,000 meters. Serial observations were made of temperature, salinity, oxygen, phosphates, silicates, nitrates, nitrites, pH and alkalinity, and the enormous amount of data collected are now being reduced and interpreted by the U. S. Fish and Wildlife Service. When the Philippine Fishery Program closed its office in 1950 it left with the Philippine Bureau of Fisheries, among various items, a compact set of oceanographic gear, equipment and supplies, as well as the research and exploratory vessel, the *David Starr Jordan.* Realizing the importance of continuing the work started by the U. S. Fish and Wildlife Service, the Bureau of Fisheries has set up a hydrology section within its division of fish culture and fisheries biology. Technical men trained in oceanography by the U. S. Fish and Wildlife Service in its offices in the Philippines and in the United States have been detailed to this section. The *David Starr Jordan,* a 50-foot, 125-horsepower diesel type vessel, has been rigged and equipped for oceanographic work, and since February of 1951 it has been exclusively used for periodic monthly oceanographic surveys of Manila Bay. The hydrology section has also begun piecewise surveys of important fishing grounds, like Malampaya Sound and the Visayan Shelf. It is deemed that its oceanographic studies will help solve some of the vital problems of Philippine fisheries. Its wealth of collected data alone will be a definite contribution to oceanographic knowledge.

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THE RATE OF ALGÆ (LUMUT) PRODUCTION IN THE DAGAT-DAGATAN SALT-WATER FISHERY EXPERIMENTAL STATION FISHPONDS.[1]

By Herminio R. Rabanal, Ricardo S. Esguerra, Juan V. Lopez, Adolfo M. Aldana, Vivencio R. Ramos, and Sergio S. Felix

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FIVE TEXT FIGURES

SUMMARY

Lumut is the Tagalog term used to designate the assemblage of filamentous green algæ (Chlorophyceæ) sometimes intermingled with filamentous blue-green algæ (Myxophyceæ) growing in brackish and salt-water ponds and composing the main bulk of the natural food of cultivated bañgos, or milkfish, *Chanos chanos* (Forskål).

The present experiment is intended to provide the basic rate of production data that may eventually be used as a standard of estimate of productivity in bañgos fishpond projects. It was undertaken at the Dagat-dagatan Salt-Water Fishery Experimental Station, Malabon–Navotas, Rizal, in six equally-sized ponds lying side by side, for a period of eight months and divided into two experimental runs of four months duration.

"Lumut" is a vernacular term (Tagalog) used for the assemblage of filamentous green algæ (Class Chlorophyceæ) and sometimes intermingled with some of the filamentous blue-green algæ (Class Myxophyceæ) which grow in brackish and salt-water ponds in the Philippines. It composes the main bulk of the food of *bañgos,* or milkfish, *Chanos chanos* (Forskål) under cultivation.

The following experiment on lumut is intended to provide a method of estimating the total production of the algæ per unit area under conditions obtaining in Philippine milkfish ponds. This should provide a basis in estimating the bañgos productivity in fishpond projects. Experimental work was undertaken from November 1, 1949 to February 27, 1950 and from July 31, 1950 to October 30, 1950 at the Dagat-dagatan Salt-Water Fishery Experimental Station, Malabon–Navotas, Rizal Province, Luzon.

[1] This investigation was made possible through funds provided by the Philippine Fishery Program of the U. S. Fish and Wildlife Service, and upon suggestion of Mr. Herbert E. Warfel, Chief, Biological and Oceanographic investigations of the Program. Sincere thanks are expressed by the writers for the valuable help rendered by Mr. Warfel and the Program he represents, without whose aid this project may not have been carried through to a successful completion.

MATERIALS AND METHODS

Six ponds of nearly identical construction, each 50 square meters in area (5 × 10 meters), and located side by side were selected for the experiment. The ponds were drained, leveled, then dried. With the gates properly screened, a limited amount of water was allowed into the ponds. Lumut growth was started in each pond by planting on the pond bottom six patches of weighed algæ of about same age stage obtained from one spot of another pond of the station.

Microscopic examination of the algæ used showed that they were predominantly composed of *Chaetomorpha* sp. with few stray filaments of *Enteromorpha intestinalis* and *Cladophora* sp. and rarely some closely adhering filamentous blue-green algæ.

Observations on temperature, pH, salinity, depth of pond water and general weather conditions were made two days each week (Tuesdays and Fridays). Two observations, one in the morning at 9:00 o'clock and the other in the afternoon at 3:00 o'clock, during these two days were made from the beginning until the end of the experiment.

These two experimental runs extended for a period of four months each, one for the high-salinity dry period (November to February) and the other for the low-salinity rainy period (July to October). The depth of the water was regulated during each period by not allowing the ponds to dry up nor go beyond a depth of one meter in order to minimize interference with the normal growth of the lumut. Renewal of the water in each of the experimental ponds was made once a week, the time for this procedure depending on the condition of the tide.

The observations on the rate of lumut growth in these six ponds were divided into three groups as follows:

GROUP A. *Ponds I and II.*—All the lumut planted in these two ponds was collected and weighed after every seven days. This lumut was returned to the same pond from where it was taken. The above procedure and other pertinent observations (meteorological and hydrographic observations) were undertaken in these two ponds during the entire span of the experiment.

GROUP B. *Ponds III and V.*—The lumut planted in these two ponds was collected and weighed after every 28 days. It was returned to the same pond and properly oriented to the condition very close to its state previous to weighing. This procedure and other pertinent observations

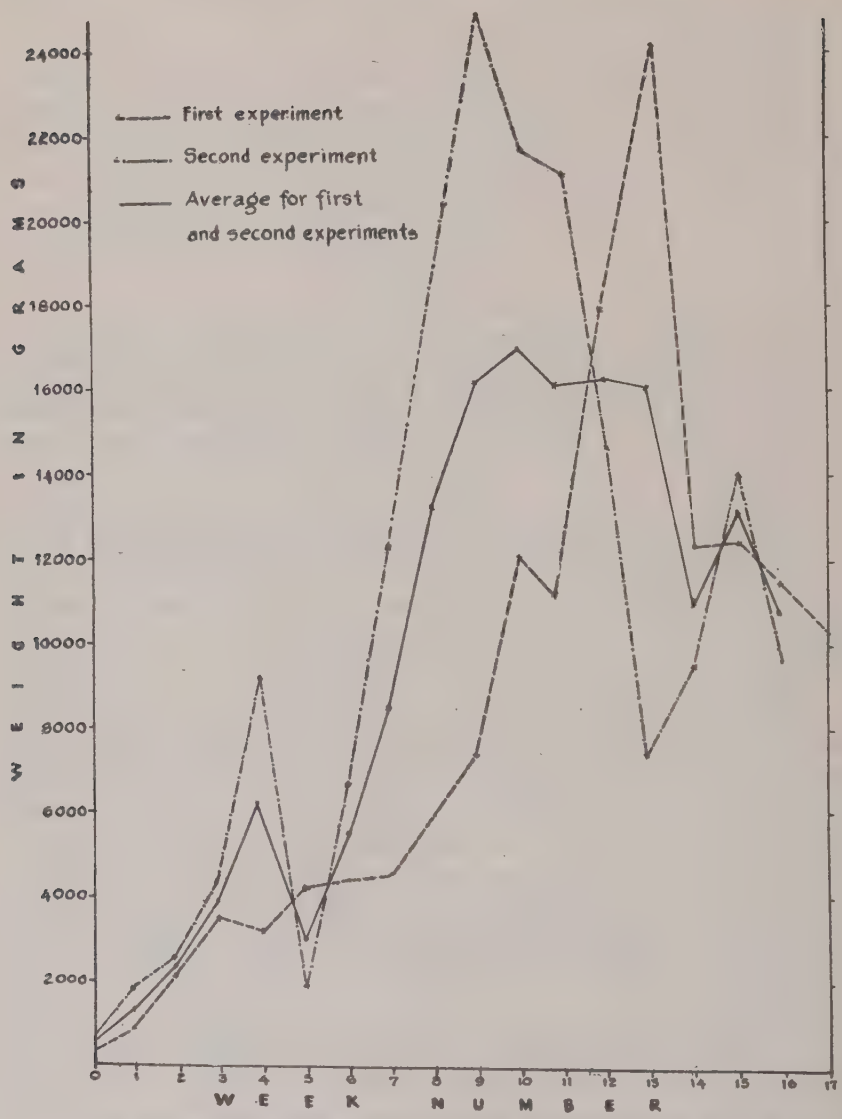

FIG. 1. Weekly increase in weight of lumut in experimental ponds I and II.

were undertaken in these two ponds during the entire span of the experiment.

GROUP C. *Ponds IV and VI.*—The lumut planted in these two ponds was collected and weighed at the end of the experimental period. Except for the above procedure the same observations as in groups A and B were made on these two ponds during the experiment.

The evaluation of the entire crop of lumut produced from each of these ponds at the end of the experiment is interpreted in terms of wet weight; that is, the weight taken as soon as water stops dripping from the algæ that have previously been hung on a line in the shade.

RESULTS AND DISCUSSION

Ponds I and II.—Tables 1 to 3 and fig. 1 show the trend of algal growth in these two ponds which was sampled weekly. Except for slight fluctuations, the rate of growth of lumut in these two ponds was very rapid during the first few weeks. In the first experiment the rapid rise begins at the start of the experiment until the thirteenth week while in the second the rapid rise lasted only up to the ninth. After a maximum growth is attained there seems to be a decline in the amount of lumut. The weekly sampling showed in some cases very wide fluctuations showing either sharp increases or decreases. This may be due to sudden environmental changes such as sudden rainfall or sudden salinity change of the water. It may also be due to the frequency of handling, these two ponds having been subjected to weekly weighing of lumut. It seems that the maximum growth attainable is better in the second experiment or during the low salinity rainy period.

TABLE 1.—*Weekly increase in weight of lumut in Experimental Ponds I and II*

[First experiment—November 1, 1949 to February 27, 1950]

Date	Duration of culture (weeks)	Weight of lumut (gm.)	Growth from initial stock	
			Weight (gm.)	Per cent
1-XI-49	Initial stock	494.2		
7-XI-49	1	914.4	420.2	85.0
14-XI-49	2	2,113.2	1,619.0	327.6
21-XI-49	3	3,586.4	3,092.2	625.7
28-XI-49	4	3,206.5	2,712.3	548.8
5-XII-49	5	4,217.3	3,723.1	753.4
12-XII-49	6	4,430.3	3,936.1	796.5
19-XII-49	7	4,548.7	4,054.5	820.4
26-XII-49	8	5,924.7	5,430.5	1,098.9
4-I-50	9	7,300.7	6,806.5	1,377.3
10-I-50	10	12,247.0	11,752.8	2,378.5
16-I-50	11	10,810.8	10,316.6	2,087.5
23-I-50	12	11,704.0	17,209.8	3,482.4
30-I-50	13	24,579.1	24,084.9	4,873.5
6-II-50	14	12,229.1	11,734.9	2,374.5
13-II-50	15	12,417.8	11,923.1	2,412.6
20-II-50	16	11,453.4	10,959.2	2,217.6
27-II-50	17	10,489.5	9,995.3	2,022.5

TABLE 2.—*Weekly increase in weight of lumut in Experimental Ponds I and II*

[Second experiment—July 10, 1950 to October 30, 1950]

Date	Duration of culture (weeks)	Weight of lumut (gm.)	Growth from initial stock	
			Weight (gm.)	Per cent
7-VII-50	Initial stock	776.0		
14-VII-50	1	1,895.6	1,119.6	144.3
21-VII-50	2	2,565.7	1,789.7	230.6
28-VII-50	3	4,365.9	3,589.9	462.6
4-VIII-50	4	9,213.7	8,437.7	1,087.3
11-VIII-50	5	1,871.1	1,095.1	141.1
18-VIII-50	6	6,690.6	5,914.6	762.2
25-VIII-50	7	12,275.5	11,499.5	1,481.9
1-IX-50	8	20,440.5	19,664.5	2,534.1
8-IX-50	9	25,061.3	24,285.3	3,129.5
15-IX-50	10	21,553.0	20,777.0	2,677.5
22-IX-50	11	21,092.4	20,316.4	2,618.1
29-IX-50	12	14,628.3	13,852.3	1,785.1
6-IX-50	13	7,300.1	6,524.1	,840.7
13-X-50	14	9,475.6	8,699.6	1,121.1
20-X-50	15	14,017.0	13,241.0	1,706.3
30-X-50	16	9,752.4	8,976.4	1,156.8

TABLE 3.—*Average weekly increase in weight of lumut in Experimental Ponds I and II*

[First and second experiments]

Duration of culture	Weight of lumut (gm.)	Growth from initial stock	
		Weight (gm.)	Per cent
Initial stock	635.1		
1	1,405.0	769.9	121.2
2	2,339.4	1,704.3	268.4
3	3,976.1	3,341.0	526.1
4	6,210.1	5,575.0	877.8
5	3,044.2	2,409.1	379.3
6	5,560.4	4,925.3	775.5
7	8,412.1	7,777.0	1,224.5
8	13,182.5	12,547.4	1,975.7
9	16,181.0	15,545.9	2,447.8
10	16,900.0	16,264.9	2,560.1
11	15,951.6	15,316.5	2,411.7
12	16,166.2	15,531.1	2,445.5
13	15,939.6	15,304.5	2,409.8
14	10,852.3	10,217.2	1,608.8
15	13,217.6	12,582.5	1,981.2
16	10,602.9	9,967.8	1,569.5
17	5,244.7	4,609.6	725.8

Ponds III and V.—Tables 4 to 6 and fig. 2 show the monthly growth in these two ponds. As in ponds I and II the rate of growth of lumut in these two ponds showed very rapid rise from the beginning of the culture period to the second month. There may be increases during the third and fourth month but these may be very gradual and even actual decreases may be registered showing a tendency to level off after attaining a

peak. Again the second experimental period of the low salinity rainy period showed higher maximum growth of lumut. Actually the highest growth of lumut for all the ponds during

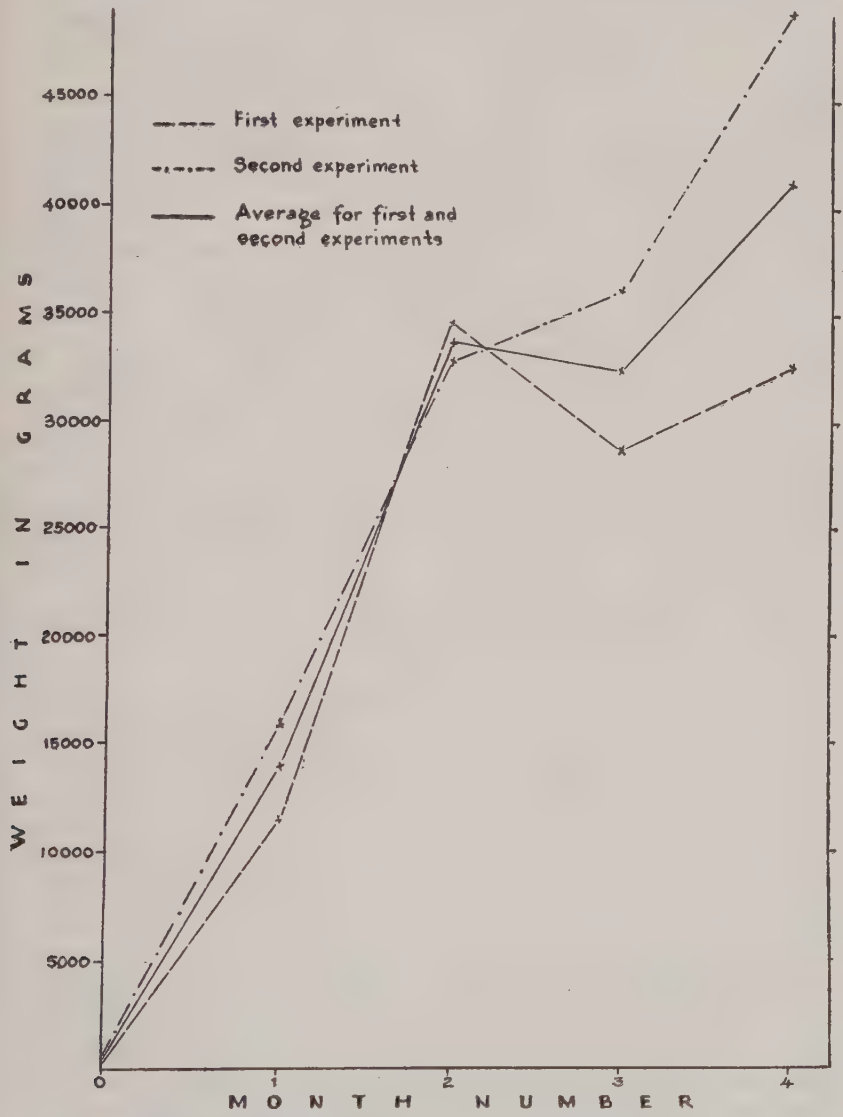

FIG. 2. Monthly increase in weight of lumut in experimental ponds III and V.

this experiment was obtained in this series with an amount of 54,658.8 grams in one pond (Pond III, 4th month) or 1,093.2 grams per square meter.

TABLE 4.—*Monthly increase in weight of lumut in Experimental Ponds III and V*

[First experiment—November 1, 1949 to February 27, 1950]

Duration of culture (months)	Weight of lumut (gm.)	Growth from initial stock	
		Weight (gm.)	Per cent
Initial stock	353.0		
1	11,731 5	11,378.5	3,223.4
2	35,182.5	34,829.5	9,866.7
3	29,033.6	28,680.6	8,164.8
4	33,055.8	32,702.8	9,264.2

TABLE 5.—*Monthly increase in weight of lumut in Experimental Ponds III and V*

[Second experiment—July 10, 1950 to October 30, 1950]

Duration of culture (months)	Weight of lumut (gm.)	Growth from initial stock	
		Weight (gm.)	Per cent
Initial stock	611.6		
1	16,329.6	15,718.0	2,561.0
2	33,311.2	32,699.6	5,346.6
3	36,798.2	36,186.6	5,916.7
4	50,689.8	50,078.2	8,188.1

TABLE 6.—*Average monthly increase in weight of lumut in Experimental Ponds III and V*

[First and second experiments]

Duration of culture months	Weight of lumut (gm.)	Growth from initial stock	
		Weight (gm.)	Per cent
Initial stock	482.3		
1	14,030.5	13,548.2	2,809.1
2	34,246.8	33,764.5	7,000.7
3	32,915.9	32,433.6	6,724.8
4	41,872.8	41,390.5	8,581.9

Ponds IV and VI.—Sampling at the end of the experiment period—4 months (Table 7 and fig. 3). After planting the initial stock of lumut these two ponds were left untouched except at the end of the experiment when the algæ were weighed to verify whether frequent handling may have something to do with their growth. The results indicate that frequent handling has no effect as shown by the fact that the rate of growth of the algæ in these ponds did not differ significantly

with those where the lumut is weighed weekly and monthly. The growth of algæ in these untouched ponds may have fluc-

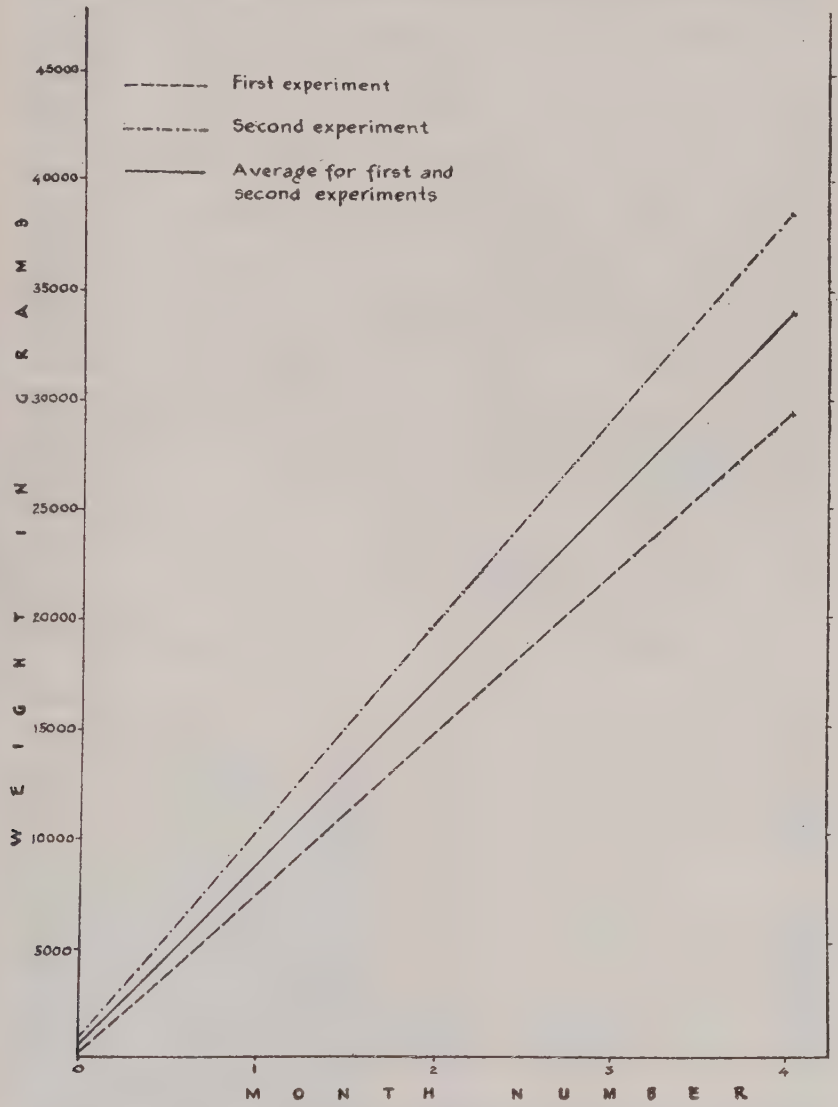

FIG. 3. Increase in weight of lumut in experimental ponds IV and VI at the end of experimental period.

tuated during the period in a similar manner as the two cases mentioned above.

TABLE 7.—*Increase in weight of lumut in Experimental Ponds IV and VI determined at the end of experimental period (four months)*

Experiment Number	Duration of culture	Weight of lumut (gm.)	Growth	
			Weight (gm.)	Per cent
First	Initial stock	384.0		
	4 months	29,895.0	29,511.0	7,685.2
Second	Initial stock	677.7		
	4 months	39,236.4	38,558.7	5,689.6
Average for first and second	Initial stock	530.8		
	4 months	34,565.7	34,034.9	6,412.0

The general meteorological and hydrographic observations (Tables 8 and 9, and fig. 4).—Considering that bangos ponds are brackish, the salinity remained at comparatively high level during the period of the first experiment—the lowest recorded being 20.6°/₀₀ and the highest 34.2°/₀₀ with an approximate average of 29.9°/₀₀. During the second experiment the salinity was comparatively much lower, ranging from 9.0°/₀₀ to 22.2°/₀₀ with an approximate average of 14.9°/₀₀. These fluctuations

TABLE 8.—*Average meteorological and hydrographic observations for Experimental Ponds I to VI*

[First experiment—November 1, 1949 to March 8, 1950]

Period (weeks)	Salinity °/₀₀	Rainfall (mm.)	Depth of pond water (cm.)	pH	Remarks
First	28.0	49.0	10.7	7.8	Water newly freshened, turbid; weather clear to passing shower.
Second	21.7	61.9	13.2	8.4	Lumut planted growing; water slightly turbid, deep; weather overcast to passing shower.
Third	27.8	8.3	10.9	8.2	Water turbid, deep; weather clear to passing shower.
Fourth	30.3	0	8.6	8.3	Good growth of algae; water turbid, low; weather generally fair.
Fifth	31.3	130.1	8.6	8.1	Water newly drained, turbid, low; weather clear to changeable,
Sixth	29.6	19.4	13.9	8.1	Water newly freshened, slightly turbid deep; weather cloudy to clear.
Seventh	23.5	0	8.9	7.7	Good growth of algae; water turbid, low; weather stormy.
Eighth	29.5	0	9.5	8.3	Water very slightly turbid, low; weather generally fair.
Ninth	27.9	21.4	6.0	8.2	Letting out water, turbid, low; weather clear to passing shower.
Tenth	29.8	11.2	11.5	8.2	Water newly freshened, turbid; weather generally fair.
Eleventh	31.2	3.8	9.5	8.0	Pond with a good growth of algae; water turbid, deep; fair weather.
Twelfth	31.7	2.3	18.6	8.2	Water slightly turbid, deep; weather generally fair.
Thirteenth	33.2	23.8	7.5	7.7	Letting out water, very turbid, low; weather clear to cloudy.
Fourteenth	31.5	0	14.9	8.0	Water newly freshened, turbid, deep; weather clear, gentle wind.
Fifteenth	32.3	0	11.6	8.3	About 80% of the pond area is covered with algae; water turbid; weather clear.
Sixteenth	33.5	4.1	12.2	7.8	Water turbid, deep; fair and very calm weather.
Seventeenth	33.3	0.3	10.3	7.5	Water turbid, low; weather clear to passing shower.
Eighteenth	33.8	0	18.4	-----	Pond newly freshened; water turbid, deep; weather generally fair.

TABLE 9.—*Average meteorological and hydrographic observations for Experimental Ponds I to VI*

[Secondary experiment—July 10, 1950 to October 30, 1950]

Period (Weeks)	Salinity °/oo	Rainfall (mm.)	Depth of fond water (cm.)	pH	Remarks
First	22.2	85.2	15.1	7.8	Pond newly planted with 6 patches of algae; water turbid, deep; weather cloudy with showers.
Second	15.2	213.5	25.0	7.7	Water newly freshened, turbid, deep; weather very stormy.
Third	12.6	100.6	38.3	7.2	Algae growing; water turbid, deep; weather very stormy.
Fourth	12.9	135.2	36.4	7.6	Water very turbid, deep; weather clear to passing showers.
Fifth	9.0	118.9	37.1	7.2	Do.
Sixth	10.1	24.4	23.8	8.0	Pond was drained; water very turbid, deep weather calm; partly cloudy.
Seventh	9.7	18.6	22.4	8.1	About 75% of the pond area is covered with algae; water turbid, deep; weather fair.
Eighth	15.3	27.9	21.5	7.9	Pond with a good growth of algae; water turbid, deep; weather cloudy to passing showers.
Ninth	19.0	37.2	22.2	8.1	Do.
Tenth	18.7	57.3	24.6	8.1	Pond newly freshened, water turbid, deep; weather clear, calm, partly cloudy.
Eleventh	18.7	70.1	22.8	8.1	Pond was drained, very turbid deep; weather overcast to changeable.
Twelfth	18.3	155.2	35.9	8.0	Water newly freshened, turbid, deep; weather calm cloudy to overcast.
Thirteenth	10.9	42.7	39.0	7.5	Algae dying, disintegrating; water very turbid, deep; weather very stormy.
Fourteenth	13.0	35.1	23.3	7.4	Pond was drained, water very turbid deep; weather generally fair.
Fifteenth	13.1	59.5	21.3	7.3	Algae dying, disintegrating, water turbid, deep; weather generally clear.
Sixteenth	20.9	18.8	27.6	7.3	Experiment due.

were mainly influenced by variation in rainfall during the period.

The pH appeared within normal limits prevailing in bañgos ponds, that is, it remained at slightly basic conditions ranging from 7.1 to 8.6 with an average of 7.7 for the first experiment and 7.2 to 8.1 with an average of 7.7 for the second experiment. The lack of abnormal values for pH shows that it is not a very important factor in lumut growth in the ponds.

The depth of the pond water was hard to control with the soil dikes and wooden gates but it remained low enough for normal growth of lumut. Rapid rises of the depth during a short duration due to rainfall or leaks from the dikes occurred, but these have not produced any significant effect on the results of the experiments.

Both experimental periods were not completely devoid of rainfall. During the first experiment, the drier period, the weekly total of rain varied from nil to 130.1 millimeters. During the second experiment, which was the rainy period, there was no week that was devoid of rain, with the weekly total ranging from as low as 18.6 millimeters to as high as 213.5 millimeters.

Except probably for salinity which remained at consistently high level during the first experimental period and comparatively lower during the second experimental period, the other factors mentioned (pH, rainfall and depth of water) did not affect lumut growth very much. The higher salinity recorded

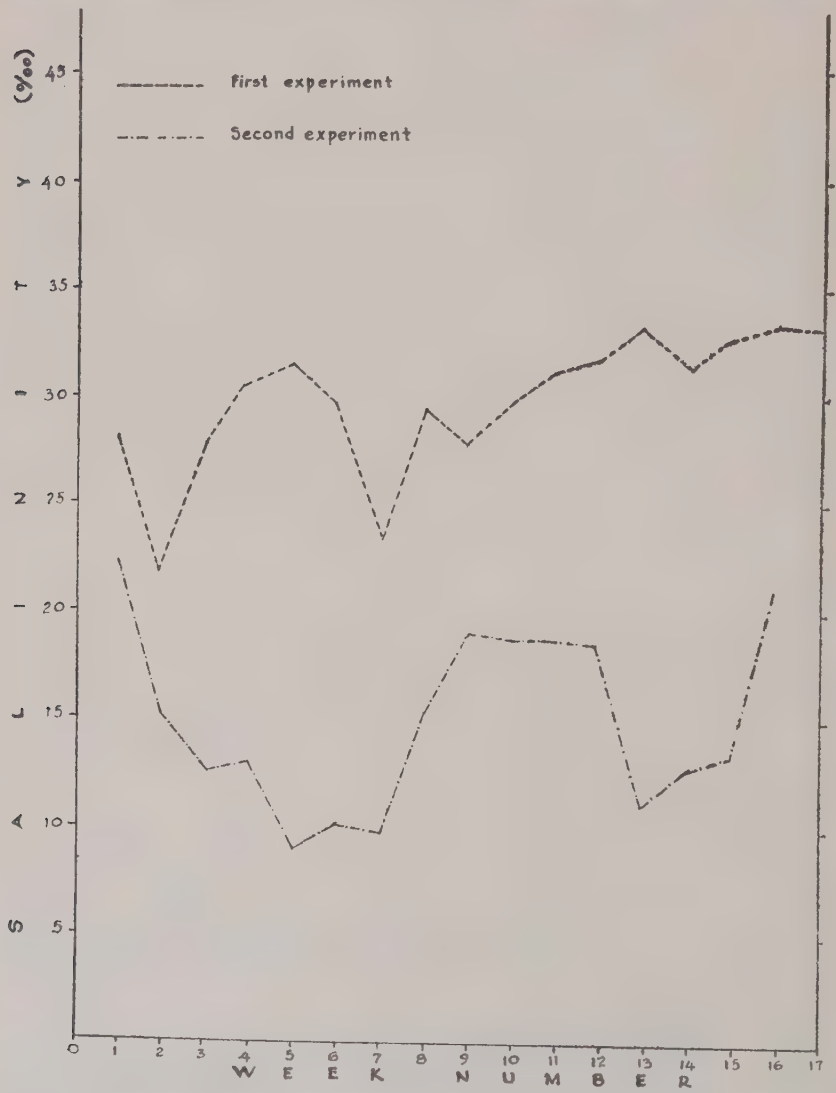

Fig. 4. Comparative salinity observations for the experimental ponds during first and second experiments.

during the period may have inhibited maximum growth of lumut during the first experimental period and explain the comparatively higher level of growth during the second experimental period.

The weather conditions varied from fair to inclement during the period. There were occasional showers, rains, winds and even storm.

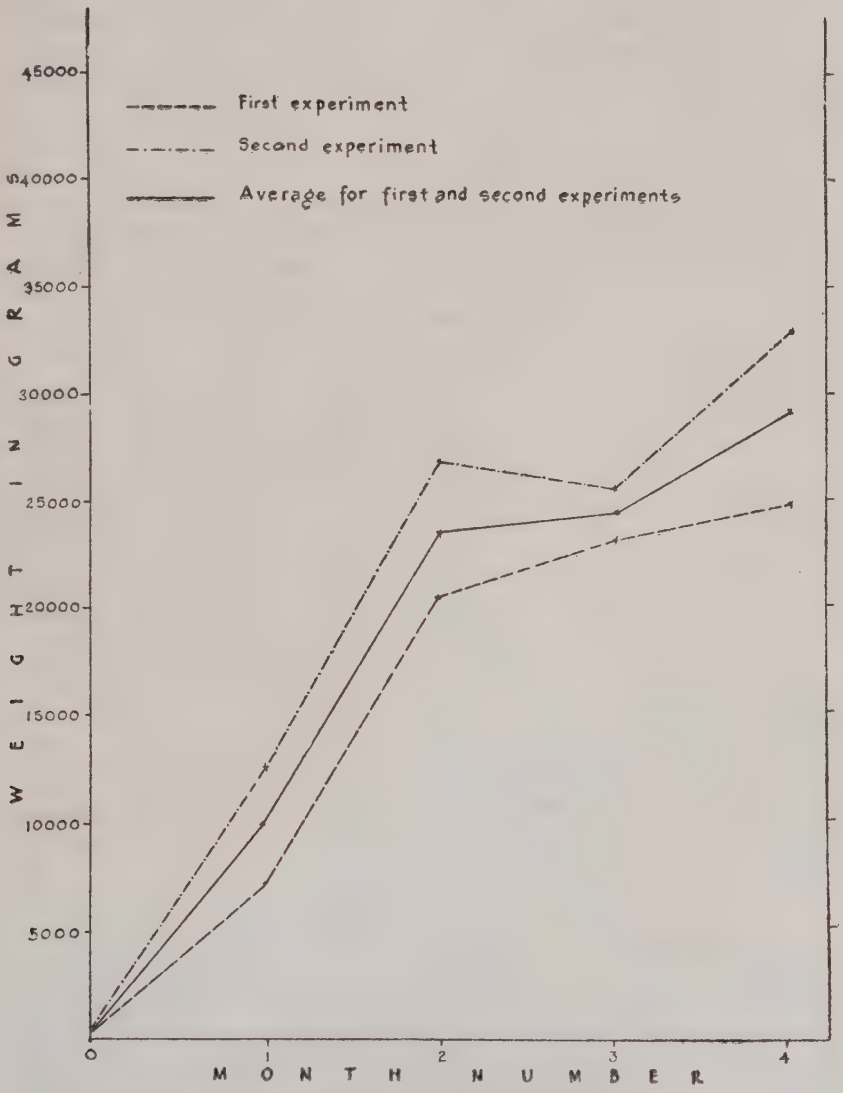

FIG. 5. Average monthly increase in weight of lumut in experimental ponds I to VI.

General observations on algæ growth (Tables 10, 11 and 12, and fig. 5).—The lumut has been observed to have undergone

a cycle of growth period and disintegration or death period as shown by regular ocular examination and the results obtained in weighing the algæ. When one of these processes prevailed, it exerts a profound effect leading in the sharp fluctuations in the rate of growth of the lumut. The duration of lumut culture necessary and the pond capacity for such growth as shown by the experiments are of value to bangos fishpond raisers.

CONCLUSIONS

All the ponds showed a very rapid rate of growth of lumut during the first few weeks but later this growth leveled off or becomes slight and even actual decreases were recorded.

TABLE 10.—*Average monthly increase in weight of lumut in Experimental Ponds I to VI*

[First experiment]

Pond number	Initial stock (gm.)	Weight after one month (gm.)	Weight after two months (gm.)	Weight after three months (gm.)	Weight after four months (gm.)
I	549.8	3,245.8	11,061.0	35,320.4	22,906.8
II	438.7	3,167.2	788.3	87.5	1
III	351.9	4,996.5	39,264.8	33,368.0	25,684.0
IV	326.0	[a]	[a]	[a]	34,020.6
V	354.2	18,466.5	31,100.3	24,699.2	40,427.0
VI	442.0	[a]	[a]	[a]	25,770.0
Totals	2,462.6	29,876.0	82,214.4	93,475.1	148,808.1
Average per pond	410.4	7,469.0	20,553.6	23,368.7	24,801.6
Average per square meter	8.2	149.4	411.0	467.3	498.4

[a] No record hence not used in computing averages

TABLE 11.—*Average monthly increase in weight of lumut in Experimental Ponds I to VI*

[Second experiment]

Pond number	Initial stock (gm.)	Weight after one month (gm.)	Weight after two months (gm.)	Weight after three months (gm.)	Weight after four months (gm.)
I	773.4	10,631.2	26,592.3	20,865.6	14,515.2
II	778.7	7,796.2	14,288.4	8,391.0	4,989.6
III	632.8	13,834.8	38,499.3	47,202.7	54,658.8
IV	693.5	[a]	[a]	[a]	29,484.0
V	590.4	18,824.4	28,123.2	26,393.8	46,720.8
VI	662.0	[a]	[a]	[a]	48,988.8
Totals	4,130.8	51,086.6	107,503.2	102,853.1	199,357.2
Average per pond	688.4	12,771.6	26,875.8	25,713.2	33,266.2
Average per square meter	13.7	255.4	537.5	514.3	664.5

[a] No record hence not used in computing averages

TABLE 12.—*Average monthly increase in weight of lumut in experimental Ponds I to VI*

[First and second experiments]

Pond number	Initial stock (gm.)	Weight after one month (gm.)	Weight after two months (gm.)	Weight after three months (gm.)	Weight after four months (gm.)
I	661.6	6,938.5	18,826.7	28,093.0	18,711.0
II	608.7	5,481.7	7,538.4	4,239.3	2,494.8
III	492.3	9,415.6	38,882.0	40,285.3	40,171.7
IV	509.7	[a]	[a]	[a]	31,752.0
V	472.3	18,645.4	29,611.7	25,546.5	43,573.9
VI	552.0	[a]	[a]	[a]	37,379.4
Total	3,296.6	40,481.2	94,858.8	98,164.1	174,082.8
Average per pond	549.4	10,120.3	23,714.7	24,541.0	29,013.8
Average per square meter	10.9	202.4	474.3	490.8	580.3

[a] No record hence not used in computing averages

Lumut growth seems to be very sensitive to changes in environmental conditions such as salinity, rainfall, and depth of pond water, as shown by the sharp rises and falls during the culture period. However, weekly sampling may also be a factor due to frequency of handling. Unfavorable and uncontrollable environmental factors may even lead to complete algal disintegration in the ponds.

The maximum growth attained for these ponds in this experiment was 54,658.8 grams per pond of 50 square meters or equivalent to 1,093.2 grams per square meter.

The average monthly growth of lumut in these ponds during this experiment, expressed in grams per square meter, is 202.4 after one month; 474.3 after two months; 490.8 after three months; 580.3 after four months. First-class bangos ponds with luxuriant growth of lumut may give figures in excess of the above, while the poorest may produce very little if at all. The above figures may be used as a gauge of pond productivity based on the rate of lumut production.

Prolonged culture of lumut may not necessarily result in increased production for the fishpond, as can be seen from this experiment. Maximum algal growth may be attainable during the period between the second and the third month. Only slight increases and even decreases in growth were noticed after this period. Therefore, it is unwise to have a prolonged culture of algæ as this may only lead to waste of time which could have been profitably spent in rearing of the fish under cultivation.

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Weekly increase in weight of lumut in experimental ponds I and II.

2. Monthly increase in weight of lumut in experimental ponds III and V.

3. Increase in weight of lumut in experimental ponds IV and VI at the end of experimental period.

4. Comparative salinity observations for the experimental ponds during first and second experiments.

5. Average monthly increase in weight of lumut in experimental ponds I to VI.

ENUMERATION OF ALGÆ IN PHILIPPINE BAÑGOS FISHPONDS AND IN THE DIGESTIVE TRACK OF THE FISH WITH NOTES ON CONDITIONS FAVORABLE FOR THEIR GROWTH.

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SUMMARY

Observation showed that out of the 43 species of algæ identified growing in Dagat-dagatan fishponds and the neighboring ponds, *Chaetomorpha* was the most common of the filamentous algæ. *Lyngbya* took the lead and followed by *Phormidium* of the blue-green algæ. Of the diatoms, *Mastogloia, Pleurosigma, Surirella, Chaetoceras, Biddulphia,* and *Nitzschia* were found predominant (Table 2).

Intestinal contents of five bañgos yielded 14 species (algæ and diatoms) recognizable and of these, *Chaetomorpha, Melosira, Navicula, Nitzschia, Pleurosigma,* and *Coscinodiscus.* Apparently these were taken upon more preferably than others, or they have not been digested when the intestinal contents were examined.

The common algæ and diatoms were sketched in six plates.

Among the 2,000 Philippine food fishes bañgos, *Chanos chanos* (Forskål), is undoubtedly the most important. The culture of this fish has developed into a thriving industry all over the Islands. Bañgos is available all the year round owing to the fact that it can be easily reared in ponds where it grows fast, being largely herbivorous. Moreover, it possesses a palatable flavor relished by the people. The fast rate of growth of bañgos together with its palatable flavor is due to the proper care it receives and the nutrition it gets from the algæ it feeds upon. At other times, cases have been reported of stunted bañgos with a sickening, earthly taste (lasang gilik). This peculiar taste may be due to the kind of food the fish has taken.

Algæ in fishponds, besides constituting the main bulk of natural food supply of the bañgos, serve as an excellent aerator in the pond. They purify and increase the biological productivity of the pond by providing shelter and attachment for epiphytic green and blue-green algæ as well as for other planktonic organisms.

Since algæ in general constitute the principal food of bangos from the fry stage until it reaches marketable size it is essential that a detailed knowledge of the different kinds of algæ in a fishpond be secured. The objects of this work are:

a. To make a systematic classification of the algæ available in a fishpond.

b. To know the conditions favorable for their rapid growth by making observations on algal culture.

c. To know what kinds of algæ are actually being used as food by the bangos by examining the stomach and intestinal contents.

The work was carried out during the first semester of the school year 1947–1948. The first collection was started on June 12, 1947 and the last on September 10, 1947 at the Dagatdagatan Fishery Experimental Station, Malabon, Rizal Province. Other collections were also made from a neighboring fishpond to make a comparison.

LITERATURE

"Diatoms have for many years been recognized as an extremely important source of food for planktonic animals." Haeckel (1890), Johnstone (1908), Lohman (1911), Gram (1912, 1930, 1931), Lebour (1921, 1922, 1923), Herdman (1923), Bigelow (1926), and Allen (1934) have published valuable discussions of the problems involved in the abundance of life in the sea.

Johnstone (1908) states: "The Diatomaceae are above all the most important organisms in the sea regarded from the point of view of their significance as producers of organic substance." The diatoms are the 'pastures of the sea' and corresponds to the 'grass of the land.' Gram (1930) wrote: "These enormous quantities of diatoms without doubt are the most important food for the pelagic copepod and indirectly for the fish larvae which develop after the great spring spawning period." Phifer (1923) likewise wrote: "Marine plants are the principal source upon which the fauna of the oceans depends for the energy necessary for existence. Undoubtedly the shore algæ produce organic material forming nutritive substance for bacteria which in turn are probably consumed by small protozoa. However, the phytoplankton are directly consumed and produce organic food in much larger quantities in as much as the real extent of their distribution is many times greater than that of the

shore forms. Of the groups in the phytoplankton such as diatoms, dinoflagellates, algal spores, cocolithopores, the first mentioned unicellular plants play the major role in the temperate seas."

Whipple (1927) states: "The fact that plankton are sensitive to changes in their environment make them good indicators of pollution and self-purification." Larger in size and more readily identifiable than bacteria, they offer an attractive means of gaging conditions of existence and with it the sanitary status of streams.

MATERIALS USED

Plankton net, research microscope, salinometer, thermometer, graduated cylinder, collecting spade, preserving bottles, presser and preserving fluids: Transeau's solution (for phytoplankton), and 10 per cent formalin.

PROCEDURE

Available algæ in both the rearing ponds and the nurseries were collected and preserved. Collections and observations were made once a week from June 10, 1947 to September 10, 1947 at the Dagat-dagatan Saltwater Fishery Experimental Station, Malabon, Rizal, and also from nearby fishponds for comparison. Specimens of phytoplankton which were collected by passing sufficient quantity of pond water through a plankton net were preserved in Transeau solution.

Lab-lab samples were collected with the aid of an improvised spade (a tin sheet attached to a long bamboo pole). These samples were then spread and dried on newspaper sheets. Before the samples were thoroughly dried they were studied under a microscope for identification and classification. Different kinds of growths were selected everytime a collection was made.

Algal growths observed on bamboo stakes, ceramic slabs, concrete gates, as well as wooden gates were collected by scrapping them with the aid of a knife. Specimens collected were spread and dried on newspaper sheets after they have been identified and classified.

Filamentous green algæ found growing on different parts of the pond were collected, spread and dried on newspaper sheets. A representative of each specimen collected was isolated, pressed, and dried.

Data were taken as to algal growth, air temperature, salinity, and water temperature including weather condition every time a collection was made.

Various sizes of bangos from different ponds were caught and dissected. The digestive organs were preserved and the stomach and intestinal contents of each specimens were studied, identified and classified. Data were also taken as to the size and weight of each fish caught.

COLLECTION RECORD NO. 1

Locality	Dagat-dagatan, Malabon, Rizal.
Date	12 June 1947.
Time	0900 A. M.
Water temperature	37° C.
Air temperature	32° C.
Salinity	10
Weather	Cloudy.

Observations:

N P[1] No. 1: Growth of dark green lab-lab was observed at the bottom but filamentous green algæ along the sides.

N P No. 2, 3: Luxuriant growth of filamentous green algæ all over these two ponds was noticeable.

N P No. 5: Thin growth along the north side of the pond but at center without any growth; thin growth on substratum at the south end was observed.

N P No. 6: Thick greenish white growth of lab-lab at the northeast side of the pond predominating.

N P No. 7: Growth of dark green lab-lab at the north and northeast side, prominent.

R P[2] No. 1: Growth of filamentous green algæ along the sides of the ponds only.

R P No. 2, 11: No algal growth seen.

Plankton Collection:

Nurseries:
Pleurosigma–A
Lyngbya

Sample A–1
Navicula
Mastogloia–A

Rearing Ponds—Sample A–2: *Peridinium venustum, Thalastiothrix, Ditylum, Coscinodiscus, Rhizosolenia, Pleurosigma, Syndra, Ceratium furca, Lauderia Mastogloia, Dinophysis, Biddulphia, Surirella, Hemiaulus,* and *Chaetocerus.*

Nursery Pond No. 6–Sample No. 1: *Oscillatoria, Mastogloia, Phormidium.*

Nursery Pond No. 7–Sample No. 2: *Lyngbya, Pleurosigma, Mastogloia, Oscillatoria* (Fine strands), *Phormidium.*

Nursery Pond No. 7–Sample No. 3: *Oscillatoria, Lyngbya, Phormidium.*

[1] NP means nursery pond.
[2] RP means rearing pond.

Nursery Pond No. 5–Sample No. 4: *Oscillatoria, Pleurosigma* (tiny), *Mastogloia.*
Nursery Pond No. 6–Sample No. 5: *Lyngbya, Oscillatoria, Mastogloia.*
Rearing Pond No. 2—Sample No. 6: *Chaetomorpha.*

COLLECTION RECORD NO. 2

Locality	Dagat-dagatan, Malabon, Rizal.
Date	18 June 1947.
Time	100 A.M.
Water temperature	30° C.
Air temperature	29.5° C.
Salinity	10.5
Weather	Sunny

Observations:

R P No. 1: Water was 2 feet deep with algal growth along sides of the pond only. Thin encrustations observed attached to the bottom which is muddy.

N P No. 5: Lab-lab growth poor. Dark bottle green color at Northwest corner of the pond. Thin growth of similar algæ collected at the center of the pond.

N P No. 6: Algae composed of thick blanket-like growth that begins to peel off from the substratum. Lab-lab is conspicuously colored yellow-green. Strands obviously old.

N P No. 7: Algæ of the dirty-green color predominating. Strands appear course with ends still attached to the substratum. Vertical growth scarcely reaching the surface of the water.

Plankton Collection:

Nurseries—Sample B–1: *Favella, Coscinodiscus, Ditylum, Pleurosigma. Ceratium furea, Dinophysis, Pediastrum.*
Rearing Pond—Sample B–2: *Peridinium, Pediastrum, Favella, Phormidium.*

Algal Collections:

Rearing Pond No. 1—Sample No. 7: *Phormidium, Anabaena, Mastogloia.*
Rearing Pond No. 2—Sample No. 8: *Enteromorpha intestinalis.*
Nursery Pond No. 5—Sample No. 9: *Lyngbya, Pleurosigma, Mastogloia.*
Nursery Pond No. 6—Sample No. 10: *Lyngbya, Pleurosigma.*

COLLECTION RECORD NO. 3

Locality	Dagat-dagatan, Malabon, Rizal.
Date	25 June 1947.
Time	0900 A.M.
Water temperature	30°C.
Air temperature	26.7°C.
Salinity	7
Weather	Showering.

Observations:

N P No. 1: Thick growth of *Chaetomorpha* covering surface of the pond. Some patches of *Enteromorpha* are entangled with the old strands of *Chaetomorpha.* No lab-lab observed on the bottom.

N P No. 5: Filamentous blue-green algæ are starting to grow towards the surface of the water at the south end of the pond.

N P No. 6: Small patches of thin growth of lab-lab could be seen all along the pond. Cakes of floating blue-green algæ floating at the south end.

N P. No. 7: Thick growth of blue-green algae is found all over the pond.

R P No. 1: Sparse growth of *Enteromorpha* along the sides.

Plankton Collection:

Nurseries—Sample C–1: *Pleurosigma* (fine A), *Lyngbya, Mastogloia, Surirella.*

Rearing Pond—Sample C–2: *Chaetoceras* (Tiny A.), *Surirella, Lyngbya, Pleurosigma, Tintinnopusis.*

Algæ:

Nursery Pond No. 5—Sample No. 11: *Lyngbya, Microcoleus.*

Nursery Pond No. 6—Sample No. 12: *Oscillatoria, Mastogloia, Spirulina, Anabaena, Phormidium, Pleurosigma.*

Nursery Pond No. 7—Sample No. 13: *Lyngbya.*

COLLECTION RECORD NO. 4

Locality	Dagat-dagatan, Malabon, Rizal.
Date	27 June 1947.
Time	0900 A. M.
Water temperature	30° C.
Air temperature	28.8° C.
Salinity	8
Weather	Sunny.

Observations:

Nursery Ponds: These ponds were dried out and lab-lab was observed to be floating on all parts of the pond. On parts of the pond has dried, the scum was seen to grow on top of the mud.

Rearing Ponds: Water was deep and algal growth was observed floating only along the sides and corners of the pond. The water has newly been changed so abundant phytoplankton was expected.

Plankton Collection:

Rearing Ponds—Sample D–7: *Chaetoceras, Biddulphia, Talassiothrix, Ditylum, Bacteriastrum, Surirella, Coscinodiscus, Rhizosolenia, Pleurosigma, Melosira, Navicula, Nitzchia, Coretron, Planktoniella, Lauderia, Clamydomonas, Marismopedia, Certium.*

Algæ:

Nursery Pond No. 6—Sample No. 15: *Lyngbya.*

Nursery Pond No. 1—Sample No. 16: *Lyngbya, Phormidium.*

Rearing Pond No. 5—Sample No. 17: *Chaetomorpha.*

Rearing Pond No. 6—Sample No. 18: *Chactomorpha.*

COLLECTION RECORD NO. 5

Locality	Dagat-dagatan, Malabon, Rizal.
Date	2 July 1947.
Time	0900 A. M.
Water temperature	29.9° C.
Air temperature	28.2° C.
Salinity	5.5
Weather	Sunny.

Observations:

N P No. 1: Thick growth of filamentous green algæ all around the pond and some patches turning brownish in color were observed.

N P No. 5, 6, 7: Algæ collected were from those attached to the substratum. No floating algæ present. Water in these ponds were deep due to heavy rain. The vertical growth of filamentous algæ were not long enough to enable them to reach the surface of the water.

R P No. 1: Algal growth found only along the sides and corners of the ponds. Some patches growing on submerged pieces of ceramics. No growth whatsoever was observed in other rearing ponds.

Phytoplankton Collection:

Rearing Ponds—*Planktoniella, Pleurosigma, Lauderia, Ditylum, Navicula, Biddulphia, Thalassiothrix, Chaetocerus, Corsthron, Bacillaria, Asterinella, Bacteriastrum, Ceratium, Favella, Coscinodiscus, Rhizosolenia, Peridinium, Nitzschia, Surirella, Gyrosigma.*

Nurseries—*Surirella, Pleurosigma, Gyrosigma, Synedra, Peridinium, Mastogloia.*

Algæ:

Nursery Pond No. 7—Sample No. 19: *Lyngbya, Oscillatoria, Mastogloia.*

Nursery Pond No. 6—Sample No. 20: *Lyngbya, Oscillatoria.*

Nursery Pond No. 5—Sample No. 21: *Lyngbya* (old strands).

COLLECTION RECORD NO. 6

Locality	Camus Fishpond, Navotas, Rizal.
Date	July 4, 1947.
Time	10:00 A.M.
Water temperature	33° C.
Air temperature	30° C.
Salinity	5
Weather	Sunny.

Observations:

N P No. 1: This pond has been drained out. Lab-lab was seen to be growing on the surface of the drying mud. A few cakes of lab-lab floating near the gate.

R P No. 6: No growth of algæ observed at the middle of the pond. A few patches of green algæ along the sides and corners.

Phytoplankton:

R P No. 6: *Thalassiothrix, Corethron, Chaetoceras, Pleurosigma, Navicula, Ditylum, Rhizosolenia, Ceratium, Coscinodiscus, Biddulphia, Peridinium.*

Nursery Pond No. 1: *Oscillatoria, Navicula, Pleurosigma, Surirella, Lyngbya, Rhizosolenia, Mastogloia.*

CNP No. 1: *Chaetomorpha, Phormidium, Tiny Pleurosigma, Mastogloia.* Sample No. 23.

CNP No. 1: Sample No. 22 *Lyngbya, Enteromorpha, Mastogloia.*

CNP No. 1: Sample No. 24 *Lyngbya* (small).

CNP No. 5: Sample No. 25: *Enteromorpha.*

CRP No. 6: Sample No. 26: *Chaetomorpha.*

COLLECTION RECORD NO. 7

Locality	Dagat-dagatan, Malabon, Rizal.
Date	9 July 1947.
Time	10:00 A. M.
Water temperature	31° C.
Air temperature	29° C.
Salinity	5
Weather	Showering.

Observations:

NP No. 1: Abundant growth of *Chaetomorpha* covering the pond but no lab-lab growth was observed.

NP No. 5, 6, 7: Water in this pond was deep and no algal growth seen.

RP No. 1, 3, 6: Growth of filamentous green algæ on the sides and corners of the pond was common.

Phytoplankton:

RP No. 6: *Biddulphia, Chaetoceras, Pleurosigma, Corethron, Pediastrum, Coscinodiscus, Navicula, Rhizosolenia, Nitzschia.*

NP No. 2: *Amphiprora, Mastogloia, Stauroneis, Pleurosigma, Navicula, Thalassiothrix.*

NP No. 2: Sample 27: *Lyngbya, Chaetomorpha, Characium* (epiphitic on *Chaetomorpha*).

NP No. 3: Sample No. 28: *Aphanocapsa, Chaetomorpha.*

RP No. 2: Sample No. 29: *Lyngbya.*

COLLECTION RECORD NO. 8

Locality	Meycauayan, Bulacan.
Date	14 July 1947.
Time	10:45 A. M.
Water temperature	33.5° C.
Air temperature	30° C.
Salinity	0
Weather	Sunny.

Observations:

Rearing Pond: There was abundant growth of *Rupia* (Digman) intertwined with growths of *Cladophora* and *Chaetomorpha.* At one corner of the pond were newly planted *Cladophora.*

Nursery Pond: This pond had growth of lab-lab at one end which was drying up.

Phytoplankton Collection:

Navicula, Pleurosigma, Amphiprora, Lyngbya.
Nursery Pond—Sample No. 30: *Anabaena.*
Sample No. 31: *Cladophora.*
Sample No. 32: *Chaetomorpha, Melosira.*
Sample No. 33: *Chaetomorpha.*
Sample No. 34: *Lyngbya.*
Sample No. 35: *Hormidium.*

COLLECTION RECORD NO. 9

Locality	Dagat-dagatan, Malabon, Rizal.
Date	15 July 1947.
Time	9:00 A. M.
Water temperature	35° C.
Air temperature	30° C.
Salinity	8
Weather	Sunny.

Observations:

NP No. 5, 6, 7: With water deep due to strong rain the previous day.

NP No. 5: Lab-lab growth very poor appearing only at corners.

NP No. 6: Thick growth of blanket algæ peeling off from substratum. Conspicuously colored green, obviously old.

NP No. 7: Young and old growths appeared together making a dirty green in color. Vertical strands observed, with ends still attached to the substratum.

NP No. 2: Thick growth of filamentous green algæ scattered in patches all over the pond. Occasionally at different parts of the pond were lab-lab growth on top of *Chaetomorpha* filaments.

RP No. 1: Lab-lab growth at the sides and corner of the pond.

RP No. 3: Patches of lab-lab along the sides.

Phytoplankton:

Rearing Pond: *Biddulphia-A, Coscinodiscus, Lauderia, Ditylum, Corethron, Nitzschia, Pleurosigma, Chaetomorpha, Thalassiothrix, Synedra.*
Nursery Pond: *Coscinodiscus, Biddulphia, Ditylum, Corethron, Pleurosigma, Thalassiothrix, Synedra, Chaetoceras.*
NP No. 3: Sample No. 36: *Chaetomorpha, Enteromorpha.*
NP No. 4: *Phormidium, Oscillatoria, Spirulina*–R.
RP No. 1: Sample No. 38: *Lyngbya.*
RP No. 2: *Gleocapsa.*
RP No. 3: Sample No. 40: *Oscillatoria.*

COLLECTION RECORD NO. 10

Locality	Dagat-dagatan, Malabon, Rizal.
Date	23 July 1947.
Time	9:00 A.M.

Water temperature	28° C.
Air temperature	27° C.
Salinity	5.5
Weather	Sunny.

Observations:

NP No. 1: No green algæ Lab-lab growth seem starting on bottom of pond.

NP No. 2, 3: Abundant growth of filamentous green algæ mostly mature *Chaetomorpha* in both ponds. Lab-lab growth on top of the filaments.

NP No. 5: Lab-lab growth on pond bottom starting to peel off.

NP No. 6: Old growth of lab-lab observed on the bottom apparently dying off.

NP No. 7: Lab-lab growth on south end of the pond obviously new growths.

RP No. 1: Filamentous green algæ along sides of the pond.

Phytoplankton:

Nursery Pond: *Surirella*–A, *Pleurosigma*–A, *Ditylum*, *Mastogloia*, *Navicula*, *Pediastrum*, *Bacillaria*, *Melosira*, *Biddulphia*.
RP No. 1—Sample No. 41: *Enteromorpha*, *Chaetomorpha*.
NP No. 2—Sample No. 42: *Chaetomorpha*, *Lyngbya*.
NP No. 6—Sample No. 43: *Lyngbya*, *Chaetomorpha*.
NP No. 6—Sample No. 44: *Lyngbya*.

COLLECTION RECORD NO. 11

Locality	Dagat-dagatan, Malabon, Rizal.
Date	August 1947.
Time	4:00 P. M.
Water temperature	34° C.
Air temperature	28° C.
Salinity	3
Weather	Overcast.

Observations:

RP No. 1: Abundant growth of *Chaetomorpha* and some *Enteromorpha* in deep water. Algal growth mostly along sides and corners of pond seen.

RP No. 2, 3, 4: No algal growth observed.

NP No. 1: Very scarce growth of lab-lab.

NP No. 2, 3: Luxuriant growth of *Chaetomorpha*, with patches of lab-lab growing on floating filaments.

Phytoplankton:

Rearing Pond: *Pleurosigma*, *Surirella*, *Ditylum*, *Mastogloia*–A.
Nursery Pond: *Pleurosigma*, *Mastogloia*, *Surirella*, *Coscinodiscus*, *Navicula*, *Amphiprora*, *Biddulphia*, *Navicula*.
NP No. 6—Sample No. 45: *Lyngbya*.
NP No. 2—Sample No. 46: *Chaetomorpha*.
NP No. 7—Sample No. 47: *Surirella*, *Anabaena*, *Lyngbya*, *Mastogloia*, *Microcoleus*, *Oscillatoria*.

NP No. 2—Sample No. 48: *Chaetomorpha, Lyngbya.*
RP No. 1—Sample No. 49: *Enteromorpha, Chaetomorpha.*

COLLECTION RECORD NO. 12

Locality	Dagat-dagatan, Malabon, Rizal.
Date	6 August 1947.
Time	10:00 A. M.
Water temperature	32° C.
Air temperature	31° C.
Salinity	5
Weather	Sunny.

Observations:

Nursery Ponds: NP Nos. 5, 6, 7, being drained for lab-lab culture. Young growths observed in NP Nos. 5 and 7. Filamentous green algæ abundant in NP Nos. 2 and 3.

Rearing Ponds: Filamentous green algæ growing in RP No. 1 mostly along the sides and corner. No algal growths observed in other rearing ponds.

Phytoplankton:

Nursery Ponds: *Pleurosigma*–A, *Surirella*–A, *Biddulphia*, *Mastogloia*, *Amphiprora*–A, *Melosira*.

Rearing Ponds: *Pleurosigma*, *Surirella*, *Amphiprora*–A, *Ditylum*, *Rhizosolenia*, *Navicula*, *Melosira*, *Mastogloia*, *Nitzschia*, *Chaetoceras*.

NP No. 2—Sample No. 51: *Chaetomorpha.*
NP No. 3—Sample No. 52: *Lyngbya*, *Anabaena.*
NP No. 3—Sample No. 53: *Enteromorpha.*
NP No. 6—Sample No. 54: *Lyngbya.*

COLLECTION RECORD NO. 13

Locality	Dagat-dagatan, Malabon, Rizal.
Date	13 August 1947.
Time	2:00 P.M.
Water temperature	34°C.
Air temperature	30°C.
Salinity	0
Weather	Showering

Observations:

Nursery Ponds: Water deep due to storm and continuous rain for two days and two nights. No lab-lab growth observed except on top of filamentous green algæ and patches on the bottom of NP Nos. 5 and 7.

Rearing Ponds: Water deep in rearing ponds. Green algæ in RP No. 1 were all under water. No other growths observed.

Phytoplankton:

Nursery Ponds: Pleurosigma, Mastogloia, Amphiprora

Rearing Ponds: *Nitzschia*, *Ditylum*, *Navicula*, *Amphiprora*, *Mastoglia*, *Biddulphia.*

RP No. 1—Sample No. 56: *Enteromorpha*, *Chaetomorpha.*

RP No. 1—Sample No. 57: *Chaetomorpha.*
RP No. 2—Sample No. 58: *Lyngbya.*
RP No. 2—Sample No. 59: *Lyngbya.*
NP No. 5—Sample No. 60: *Chaetomorpha.*
NP No. 6—Sample No. 61: *Lyngbya.*
NP No. 7—Sample No. 62: *Lyngbya.*

COLLECTION RECORD NO. 14

Locality	Dagat-dagatan, Malabon, Rizal.
Date	20 August 1947.
Time	2:00 P.M.
Air temperature	31°C.
Water temperature	28°C.
Salinity	3
Weather	Cloudy.

Observations:

Nursery Ponds: No algal growth in RP No. 1. Green algæ mostly *Chaetomorpha* abundant in RP No. 2, 3 conspicuously old with a yellow greenish color. Very scarce algal growth in NP No. 4. New growths of Lab-lab observed in Nos. 5 and 6. Floating lab-lab in NP No. 7, dark green in color.

Rearing Ponds: Old filaments of *Chaetomorpha,* yellow green in color intertwined with young filaments of floating Enteromorpha at different parts of the pond specially along the sides and corners.

No algal growth in other rearing ponds observed.

Phytoplankton:

Rearing Ponds: *Biddulphia, Nitzschia, Pleurosigma, Chaetoceras, Navicula–A, Mastogloia, Ditylum, Chamaesiphon, Surirella, Coscinodiscus.*

Nursery Ponds: *Amphiprora, Melosira, Pleurosigma, Navicual, Nitzschia, Amphora, Mastogloia Chaetoceras.*

RP No. 1—Sample No. 63: *Chaetomorpha, Enteromorpha.*
NP No. 1—Sample No. 64: *Chaetomorpha, Enteromorpha.*
NP No. 2—Sample No. 65: *Lyngbya, Chaetomorpha.*
NP No. 5—Sample No. 66: *Lyngbya, Microcoleus.*
NP No. 6—Sample No. 67: *Lyngbya, Microcoleus.*

COLLECTION RECORD NO. 15

Locality	Dagat-dagatan, Malabon, Rizal.
Date	27 August 1947
Time	9:00 A.M.
Water temperature	31°C.
Air temperature	27°C.
Salinity	2
Weather	Cloudy.

Observations:

Nursery Pond No. 1: No lab-lab growth observed today.

Nursery Pond No. 2, 3: Luxuriant growth of filamentous green algæ (*Chaetomorpha*) in both ponds. Lab-lab growth observed on top of filamentous green algæ.

NP No. 46: No algal growth visible.

NP No. 5, 6, 7: Growth of *Rupia* observed. Lab-lab growth very scarce.

RP No. 1: *Chaetomorpha* and *Enteromorpha* growth observed along sides and corner of the pond.

No algal growth in other ponds.

Phytoplankton:

Rearing Ponds: *Chaetoceras–A, Ditylum, Merismopedia–B, Biddulphia, Melosira, Coscinodiscus, Pleurosigma, Thalassiothrix, Surirella, Rhisosolenia, Nitzschia, Mastogloia, Navicula.*

Nursery Ponds: *Pleurosigma, Surirella, Navicula, Coscinosdiscus, Biddulphia, Ditylum, Chaetoceras.*

RP No. 1—Sample No. 69: *Enteromorpha.*
RP No. 1—Sample No. 70: *Cladophora.*
NP No. 2—Sample No. 71: *Lyngbya.*
NP No. 4—Sample No. 72: *Lyngbya.*
NP No. 6—Sample No. 73: *Lyngbya, Chaetomorpha.*

COLLECTION NO. 16

Locality	Dagat-dagatan, Malabon, Rizal.
Date	3 September 1947.
Time	10:00 A.M.
Water temperature	29°C.
Air temperature	28°C.
Salinity	0
Weather	Sunny.

Observations:

NP No. 1: No algal growth visible whatsoever.

NP Nos. 2, 3: Abundant, ripe-yellow filamentous green algæ with occasional growths of lab-lab on top of filaments.

NP No. 4: No algal growth.

NP Nos. 5, 6, 7: Very scarce growth of lab-lab but abundant growth of *Rupia* (digman) due to low salinity of water.

RP No. 1: *Enteromorpha, Chaetomorpha,* and *Cladophora,* growing along sides and corners of pond.

RP No. 2: No algal growth except on pieces of ceramics that have been submerged in water.

RP Nos. 3–11: No algal growth.

NP No. 2. Gelatinous bottle-green algæ collected. Found growing among the roots of grasses partially submerged in water.

Phytoplankton:

Rearing Ponds: *Ditylum–A, Surirella, Pleurosigma, Coscinodiscus, Nitzschia, Melosira, Navicula, Biddulphia, Amphiprora, Chaetoceras.*

Nursery Ponds: *Biddulphia–A, Coscinodiscus–A, Pleurosigma, Ditylum, Thalassiothrix, Lauderia, Melosira.*

NP No. 5—Sample No. 74: *Lyngbya, Melosira.*
NP No. 3—Sample No. 75: *Lyngbya, Cladophora.*
NP. No. 2—Sample No. 76: *Cladophora, Lyngbya.*
NP No. 2—Sample No. 77: *Aphanocapsa.*
RP No. 2—Sample No. 78: *Chaetomorpha.*

COLLECTION RECORD NO 17

Locality	Dagat-dagatan, Malabon, Rizal.
Date	10 September 1947.
Time	10:00 A. M.
Water temperature	30°C.
Air temperature	28°C.
Salinity	2
Weather	Sunny.

Observations:

NP No. 1: No algal growth.

NP Nos. 4, 5: Luxuriant growth of mature filamentous green algæ with patches of lab-lab on top of floating filaments. Intermingled with the green algæ are growth of *Rupia* and *Chara.*

Nursery Pond No. 4: No algal growth.

Nursery Pond Nos. 5, 6, 7: These ponds were drained and dried, preparatory to cultivation of lab-lab.

Rearing Pond No. 1: Filamentous green algæ, *Chaetomorpha* and *Cladophora* growing luxuriantly. Growth of Rupia abundant.

RP Nos. 2–11: No algal growth except on bamboo stakes.

Phytoplankton:

Rearing Ponds: *Ditylum, Navicula, Surirella, Pleurosigma, Merismopedia, Melosira, Oscillatoria.*

Nursery Ponds: *Melosira–A, Amphiprora, Surirella, Chaetoceras, Spirulina, Coscinodiscus, Pleurosigma, Navicula.*

NP No. 2—Sample No. 79: *Cladophora, Lyngbya.*
NP No. 1—Sample No. 80: *Nostoc, Cladophora.*
NP No. 1—Sample No. 81: *Cladophora, Lyngbya.*

COLLECTION RECORD

Stomach and Intestinal Contents of Bañgos

Fish No. 1

Locality	RP No. 1, Dagat-dagatan.
Date	4 October 1947.
Total length	6.9 cm.
Standard length	5.3 cm.
Depth	1.3 cm.

Stomach contents: *Chaetomorpha, Pleurosigma, Navicula, Lyngbya, Achnanthes.*

Intestinal contents: *Chaetomorpha, Navicula.*

Fish No. 2

Locality	RP No. 9, Dagat-dagatan.
Date	5 October 1947.
Total length	56 cm.
Standard length	41 cm.
Depth	9.5 cm.

Stomach contents: *Pleurosigma, Navicula, Coscinodiscus*

Intestinal contents: None

Fish No. 3

Locality	RP No. 7, Dagat-dagatan.
Date	8 October 1947.
Total length	42.5 cm.
Standard length	30.0 cm.
Depth	7.0 cm.

Stomach contents:*Chaetomorpha, Lyngbya, Enteromorpha, Melosira, Cladophora, Coconeis, Navicula, Achnanthes.*

Intestinal contents: *Cladophora, Chaetomorpha, Melosira, Lyngbya, Coconeis, Navicula.*

Fish No. 4

Locality	RP No. 1, Dagat-dagatan.
Date	28 October 1947.
Total length	27 cm.
Standard length	22 cm.
Depth	7 cm.

Stomach contents: *Coscinodiscus*–A, *Melosira*,–A, *Chaetomorpha, Enteromorpha, Navicula, Pleurosigma, Mastogloia, Oscillatoria, Lyngbya, Rupia.*

Intestinal contents: *Melosira*–A, *Coscinodiscus, Chaetomorpha, Navicula, Mastogloia.*

Fish No. 5

Locality	RP No. 1, Dagat-dagatan.
Date	28 October 1947.
Total length	26 cm.
Standard length	21 cm.
Depth	6 cm.

Stomach contents: *Melosira*–A, *Navicula*–A, *Achnanthes, Lyngbya, Coscinodiscus, Chaetomorpha, Amphiprora, Nitzschia, Mastogloia, Rupia.*

Intestinal contents: *Melosira, Coscinodiscus, Cladophora, Chaetomorpha,* (disintegrating), *Enteromorpha, Navicula, Amphora, Achnanthes, Oscillatoria.*

SYSTEMATIC CLASSIFICATION

Division—SCHIZOPHYTA.

Class—Myxophyceae.

Order—Chroococcales.

Family—Chroococcaceae.
Genus—*Aphanocapsa.*
Genus—*Merismopedia.*
Order—*Hormogonales.*
Suborder—Homocystineae.
Family—Oscillatoriaceae.
Genus—*Oscillatoria.*
Genus—*Spirulina.*
Genus—*Phormidium.*
Genus—*Lyngbya.*
Genus—*Microcoleus.*
Family—Nostocaceae.
Genus—*Nostoc.*
Genus—*Anabaena.*

Division—CHRYSOPHYTA.

Class—Bacillarophyceae.
Section—Centriceae.
Subfamily—Discoideae.
Tribe—Coscinodisceae.
Substribe—Melosirinæ.
Genus—*Melosira.*
Substribe—Coscinodiscinæ.
Genus—*Coscinodiscus.*
Genus—*Planktoniella.*
Subtribe—Lauderinae.
Genus—*Lauderia.*
Genus—*Corethron.*
Subtribe—Rhizosoleniinae.
Genus—*Rhizosolenia.*
Subfamily—Biddulpheideae.
Tribe—Chaetocereae.
Genus—*Chaetoceros.*
Tribe Biddulphiaeae.
Subtribe—Triceratineae.
Genus—*Ditylum.*
Substribe—Biddulphinæ.
Section—Pennates.
Subsection—Araphidae.
Subfamily—Fragilarioideae.
Tribe—Fragilarieae.
Subtribe—Fragilariinae.
Genus—*Synedra.*
Genus—*Thalassiothrix.*
Subsection—Monoraphidae.
Subfamily—Achnantheideae.
Tribe—Achnantheae.
Genus—*Achnanthes.*

Subsection—Biraphidae.
Subfamily—Naviculaoideae.
Tribe—Naviculeae.
Genus—*Navicula.*
Genus—*Pleurosigma.*
Genus—*Gyrosigma.*
Genus—*Mastogloia.*
Tribe—Amphiproreae.
Genus—*Amphiprora.*
Subfamily—Nizschioideae.
Tribe—Nitzschieae.
Genus—*Nitzschia.*
Subfamily—Surirelleideae.
Tribe—Surirelleae.
Genus—*Surirella.*

Division—CHLOROPHYTA.
Class—Chlorophyceae.
Order—Ulvales.
Family—Ulvaceae.
Genus—*Enteromorpha.*
Order—Ulothricales.
Suborder—Cladophorieae.
Family—Cladophoraceae.
Genus—*Cladophora.*
Genus—*Chaetomorpha.*

Division—PYRROPHYTA.
Class—Dinophyceae.
Order—Dinoflagellata.
Family—Peridinidae.
Genus—*Peridinium.*
Genus—*Ceratium.*
Family—Dinophysidae.
Genus—*Dinophysis.*

FIELD OBSERVATION OF THE LOCAL CULTIVATION OF ALGÆ

Preparation of the nursery pond.—The pond is first dried by letting out all water during low tide. Water that still remains at the gate or its vicinity is bailed or pumped out. All dirt and debris like grasses and other weeds are removed. Animals such as eels and snakes are eradicated. The pond bed is then thoroughly leveled with the use of a wooden rake and exposed to sunlight for a period of two weeks. Exposure for such a period serves to kill bangos fry enemies, such as the eggs and fry of predatory species. It also helps to hasten the growth of blue-green algæ on the mud crust.

After exposing the pond bottom for such a length of time and the growth of lab-lab is observed, water is allowed to enter into the pond to a depth of one or two inches. The scum that has formed tends to float or peel off, and the patches that do not float just thickens. This scum or mudcrust which is locally known as *lab-lab* serves as the food of bangos fry.

Preparation of the rearing pond.—The water of a rearing pond which is intended for the cultivation of "lumut" (green algæ) is first drained out. The pond is then washed two or three times by letting water in and out of the pond. After washing, the pond bottom is exposed to sunlight for two weeks. During this period, predatory species such as eels and snakes are removed from the pond bed. Whenever there is luxuriant growth of lab-lab forming on the mud crust it is scraped off. This is done to prevent the lab-lab from forming a blanket over the newly growing lumut green algæ.

After exposing the pond bed for two weeks, water is allowed to enter into the pond to a depth of four inches. Filamentous green algæ, *Chaetomorpha, Cladophora,* and *Enteromorpha,* are then planted at a distance of two meters. In ponds where green algæ has newly been planted, the water is kept at a depth of not more than six inches. This is done to allow the algæ to grow and have a more firm attachment to the bottom. Whenever the water in the pond becomes deep, the newly growing green algæ floats and are pulled off from their attachment, so it is necessary to keep the water at a constant low depth.

RECOMMENDATIONS

1. It is recommended that experiments be carried on the use of artificial fertilizers in the cultivation of algæ especially those relished by the fish.

2. That further study be made on the practicability of transplanting dried lumut and lab-lab.

3. That studies be made to determine the relationship of the rate of growth of bangos to the rate of consumption of algæ.

4. That a more detailed research be done on the qualitative and quantitative analysis of planktonic organisms present in fishponds during the different seasons of the year.

TABLE 1.—*Collection records arranged as to places.*

C.R.	Date	Locality	Time	Weather	H_2O temperature	Air temperature	Salinity
1	12 June	Dagat-dagatan	9:00 A.M.	Cloudy	37° C.	32° C.	10
2	18 June	do	10:00 A.M.	Sunny	30° C.	29.5° C	10.5
3	25 June	do	9:00 A.M.	Showering	30° C.	28.7° C	7
5	2 July	do	9:00 A.M.	Sunny	29.9° C.	28.2 °C.	5.5
7	9 July	do	9:00 A.M.	Showering	31° C.	29° C.	5
9	15 July	do	9:00 A.M.	Sunny	35° C.	30° C.	8
10	23 July	do	9:00 A.M.	do	28° C.	27° C.	5.5
11	1 August	do	11:00 A.M.	Overcast	34° C.	28° C.	3
12	6 August	do	10:00 A.M.	Sunny	32° C.	31° C.	5
13	13 August	do	2:00 P.M.	Showering	34° C.	30° C.	0
14	20 August	do	2:00 P.M.	Cloudy	31° C.	28° C.	3
15	29 August	do	9:00 A.M.	do	31° C.	27° C.	2
16	3 September	do	10:00 A.M.	Sunny	29° C.	29° C.	0
17	10 September	do	10:00 A.M.	do	30° C.	28° C.	2
4	27 June	Camus F. P.	9:00 A.M.	do	30° C.	28.8° C.	8
6	1 July	do	10:00 A.M.	do	33° C.	30° C.	5
8	14 July	Meycawayan	10:00 A.M.	do	33.5° C.	30° C.	0

TABLE 2.—*Dagat-dagatan rearing pond.*

Kinds of algæ	12 June 1948	18 June 1948	25 June 1948	2 July 1948	9 July 1948	15 July 1948	23 July 1948	1 Aug.	6 Aug. 1948	13 Aug. 1948	20 Aug. 1948	27 Aug. 1948	3 Sept. 1948	10 Sept. 1948
Chlorophyceae.														
Enteromopha		x						x		x	x	x		
Chaetomorpha	xx	x						xx		xx	x		x	
Cladophora												x		
Pediastrum					x									
Myxophyceae.														
Anabaena		x												
Aphanocapsa														
Lyngbya			x		x	x	x							
Merismopedia														x
Microcoleus														
Nostoc														
Oscillatoria							x							x
Phormidium		xx												
Spirulina														
Bacillariaceae														
Achnanthes														
Amphiprora									xxx	x			x	
Asterionella				x										
Bascillaria														
Bacteriastrum				x										
Biddulphia	x			x	x	xxx	x			x	x	x	x	
Chaetoceras	x		xxx	x	x	x			x		x	x	x	
Corethron				x	x	x								
Coscinodiscus	xx			x	x	x	x				x	x	x	
Ditylum	x			x		x	x	x	x	x	x	x	xx	x
Gleocapsa														
Gyrosigma				x			x							
Hemiaulus	x													
Lauderia	x			x		x	x							
Mastogloia	x	x						xxx	x	x	x			
Melosira									x				x	x
Navicula				x	x		x		x	x	x	x	x	x
Nitzschia				x		x	x		x	x	xxx		x	
Planktoniella				x	x									
Pleurosigma	x				x	x	xxx	xxx	xxx		x	x	x	x
Rhizosolenia	x		x	x	x				x					
Stauroneis														
Surirella	x		x	x				x	x			x	x	x
Synedra	x					x					x			
Thallasionema														
Thalassiothrix	x			x		x								

TABLE 3.—*Dagat-dagatan nursery pond.*

Kinds of algae	12 June 1948	18 June 1948	26 June 1948	2 July 1948	9 July 1948	16 July 1948	23 July 1948	1 Aug. 1948	6 Aug. 1948	13 Aug. 1948	20 Aug. 1948	27 Aug. 1948	3 Sept. 1948	10 Sept. 1948
Chlorophyceae														
Enteromorpha						x	x		x		x			
Chaetomorpha					x	xx	xxx	xxx	xxx	xx	xx	xx		
Cladophora														xxx
Pithophora		x					x							
Myxophyceae														
Anabaena			x					x	x					
Aphanocapsa					x								x	
Lyngbya	xx	xx	xx	xx	x		xx	x		xxx	xx	xx	xx	
Merismopedia												x		
Microcystis			x								x			
Nostoc														xxx
Oscillatoria	xx		x	xx		x								
Phormidium	x		x			xx								
Spirulina			x			x								
Bacillariaceae														
Achnanthes														
Amphiprora					x			x	xxx	x	x			
Amphora											x			
Asterionella														x
Biddulphia						x	x	x	x			x	xxx	
Chaetoceros						x					x	xxx		
Corethron						x								
Coscinodiscus	x	x					x		x				x	xx x
Diploneis		x				x	x					x	x	
Gloeocapsa														xx
Gyrosigma				x										
Hemiaulus														
Lauderia													x	
Mastogloia	xxx	x	xx	x	x		x	xx	x	x	x	x		
Melosira							x		x		x	x	xx	xxx
Navicula	x				x		x	x			x	x		x
Nitzschia											x	x		
Pinnularia														
Pleurosigma	xxx	xx	xxx	x	x	x	xxx	x	xxx	x	x	x	x	
Rhizosolenia												x		
Stauroneis					x									
Surirella				x			xxx	x	xxx			x		x
Synedra				x		x								
Thalassionema														
Thalassiothrix					x	x						x	x	

TABLE 4.—*Types of algæ in ponds and of algæ in the stomach and intestines of bañgos.*

Kinds of algæ	Neighboring ponds				Stomach and intestinal contents				
	Camus pond	27 June 1948	Maycawayan	14 July 1948	Fish No. 1	Fish No. 2	Fish No. 3	Fish No. 4	Fish No. 5
Chlorophyceae									
Enteromorpha	x						x	x	x
Chaetomorpha	x	x		xx		xx	x		x
Cladophora				x			x		x
Pediastrum									
Myxophyceae									
AnAbaena				x					
Aphanocapsa									
Lyngbya	xxx	x		xx	x	x		x	x
Merismopedia		x							
Microcoleus									
Nostoc									
Oscillatoria	x							x	
Phormidium		x							
Spirulina									
Bacillariaceae									
Achnanthes					x		x		x
Amphora									x
Amphiprora				x					
Asterionella									
Bacteriastrum		x							
Biddulphia	x	x							
Chaetoceras	x	x							
Coconeis							x		
Corethron	x	x							
Coscinodiscus	x	x				x		xxx	x
Ditylum	x	x							
Gleocapsa									
Gyrosigma									
Mastogloia	xxx							x	x
Melosira		x		x			x	xxx	xx
Navicula	xx	x		x	xxx	x	x	x	x
Nitzschia		x							x
Lauderia		x							
Planktoniella		x							
Pleurosigma	xx	x		x	xxx	xx		x	
Rhizosolenia	xx	x							
Stauroneis									
Surirella	x	x							
Synedra									
Thalassionema									
Thalassiothrix	x	x							

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COMPARATIVE CAPACITIES OF VARIOUS PLATING MEDIA FOR SATISFYING THE CULTURAL REQUIREMENTS OF AEROBIC BACTERIA IN MATERIALS OF MARINE ORIGIN.

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SUMMARY

Eight formulas of plating medium have been studied to determine their comparative abilities in satisfying the cultural requirements of the bacterial population in materials of marine origin. Five series of experiments comprising a total of 56 trials have been performed. The procedure and technique employed are thoroughly discussed.

Media prepared with "aged" sea water as menstruum were found to be definitely superior to those prepared with distilled water, alone or with NaCl.

The effect of different diluents, various plating temperatures of the medium and various incubation temperatures on the total bacterial colony counts were also investigated.

The principal problem which arises when planning any bacteriological investigation requiring quantitative bacterial determination in materials of marine source is the selection of a medium that gives the most nearly accurate picture of their bacterial population. Such a medium should satisfy the cultural requirements of a great number of microorganisms in the material under study.

The large number of nutrient media recommended for this purpose attests to the basic importance of an appropriate medium for enumerating marine bacteria. Comparative studies conducted by the Scripps Institution of Oceanography, on a large number of media which have been recommended by various workers show that medium 2216 (vide infra) is one of the best for supporting the growth of a maximum number of bacteria and for ability to reproduce the plate counts on marine material (ZoBell, 1946).

Fischer (cited by ZoBell, 1942) recommended a medium which differs slightly from 2216. This medium contains 1.0 per cent peptone and 0.5 per cent fish extract in sea water. ZoBell (1941), however, failed to produce any increase in plate counts by fortifying Medium 2216 with various fish extracts. Lloyd (cited by ZoBell, 1942) following experiments with ex-

tracts of various marine organisms including fish, states that they are not essential.

Bacteriologists of the Woods Hole Oceanographic Institution (cited by ZoBell, 1946) adopted the following formula which consistently gave them the best results:

Peptone	g.	1.0
Glucose	do	1.0
K_2HPO_4	do	0.05
Agar	do	15.0
Sea Water	cc.	1000.0

Berkeley, Lipmann, Bavendamn, Gee, and others (cited by ZoBell, 1942) used media containing nitrate. ZoBell (1941), using 0.005 to 0.10 per cent potassium nitrate, was unable to demonstrate any effect, "beneficial or detrimental" on the quantitative or qualitative plate count.

Kiser and Beckwith (1944) in their study of the bacterial flora of mackerel, compared mackerel infusion with 2216 medium for quantitative bacteriological examination and found the latter superior.

To the writer's knowledge no work on this particular phase of bacteriology has been conducted under local conditions. In view of the necessity of a suitable medium for making total and comparative counts of the shellfish-growing water and oysters from the Bureau of Fisheries oyster farm at Binakayan, in connection with investigations being conducted on these materials, the following series of experiments were performed.

MATERIALS

Media.—Eight formulas of plating medium were tried in this study.

Formula 1—2216 Medium

Bacto peptone	g.	5.0
Ferric phosphate	do	0.1
Bacto-agar	do	15.0
Sea Water ("aged")	cc.	1,000.0

pH not adjusted, about 7.6 after sterilization.[1]

Formula 2—Nutrient agar[2] with sea water menstruum

Bacto-beef extract	g.	3.0
Bacto-peptone	do	5.0

[1] All media were sterilized in the autoclave at 15 lbs. pressure for 20 minutes.

[2] Bacto-nutrient broth (Difco-dehydrated) was used with the other ingredients, as required in the formula, added.

Bacto-agar	g.	15.0
Sea Water ("aged")	cc.	1,000.0

pH adjusted to 7.8 before sterilization.

Formula 3—Nutrient agar with 0.5 per cent sodium chloride

Bacto-beef extract	g.	3.0
Bacto-peptone	do	5.0
Bacto-agar	do	15.0
Sodium chloride	do	5.0
Distilled water	cc.	1,000.0

pH adjusted to 7.8 before sterilization.

Formula 4—Nutrient agar with 15 per cent sodium chloride

Bacto-beef extract	g.	3.0
Bacto-peptone	do	5.0
Bacto-agar	do	15.0
Sodium chloride	do	150.0
Distilled water	cc.	1,000.0

pH adjusted to 7.8 before sterilization.

Formula 5—"Alamang" infusion agar.[3]

Alamang infusion	cc.	1,000.0
Bacto-peptone	g.	5.0
Bacto-agar	do	15.0

Adjusted to pH 7.8 before sterilization

Formula 6—Fish infusion agar.[4]

Fish infusion	cc.	1,000.0
Bacto-peptone	g.	5.0
Bacto-agar	do	15.0

Adjusted to pH 7.8 before sterilization.

Formula 7—Eyre's Oyster Agar (1944).[5]

Oyster infusion	cc.	1,000.0
Agar	g.	20.0

pH not adjusted about 7.6.

Formula 8—A modification of the formula recommended by the Woods Hole Oceanographic Institution.[6]

Peptone	g.	1.0

[3] Preparation of "alamang" infusion. To 500 g. fresh "alamang' (post-larval stages of Penaeidae) 1,000 cc. of "aged" sea water was added. The mixture was blended and infused overnight in the refrigerator, and then boiled and strained through cheesecloth and then through filter paper. The infusion was sterilized at 15 lbs. pressure for 20 minutes.

[4] The procedure for the preparation of fish infusion is the same as given for "alamang" infusion. Dalagang bukid (*Caesio caerulaureus*, Lacépéde) flesh was used, this being one of the most easily available at the time.

[5] The procedure was slightly modified by infusing the oysters in the refrigerator overnight instead of at 37° C. for 30 minutes. "Aged" sea water was used.

[6] The original formula calls for K_2HPO_4.

Glucose	g.	1.0
KH_2PO_4	do	0.05
Agar	do	15.0
Sea Water	cc.	1,000.0

pH not adjusted, about 7.6 after sterization.

Sea water.—Whenever sea water was required, filtered, sterile, "aged" sea water[7] was employed.

Source of specimens plated.—A total of 56 specimens were plated. Fifty of these were obtained from the Bureau of Fisheries oyster farm at Binakayan. These included 34 shellfish-growing water specimens and 16 oyster specimens. The other six included one of "aged" sea water, one of pooled "alamang" (postlarval stages of Penaeidæ), three of sea water obtained at the breakwaters in Manila Bay, and one specimen of pooled intestinal contents of "dalagang bukid" (*Caesio caerulaureus* Lacépéde).

All specimens were obtained and handled aseptically.

METHODS

Five series of experiments comprising a total of 56 trials were conducted. In each series a given group of media was examined for the number of bacterial colonies growing in each.

Preparation of specimens.—Ten-fold dilutions of the specimens were prepared with sterile "aged" sea water. One milliliter or fractions thereof of the two highest ten-fold dilutions was plated separately in each medium being compared in a given trial. Considerations calculated to facilitate an accurate enumeration of the bacterial colonies growing in the various media employed determined the choice of the dilutions plated. For instance, in the first few trials with oysters, 0.25 milliliter of a 1:100 dilution and 0.5 milliliter of a 1:1000 dilution were plated. Due to difficulties encountered in taking the counts in some of the plates, higher dilutions (0.25 milliliter of 1:1000 and 0.5 milliliter of 1:10,000) were tried and in the later trials still higher dilutions (0.25 milliliter of 1:10,000 and 0.5 milliliter of 1:100,000) were plated.

Technique for plating (plating temperature of media).—The technique evolved and employed was designed to reduce the actual temperature of the medium to a minimum without

[7] Fresh sea water filtered through paper and aged in glass bottles in the dark and at room temperature for at least three weeks before being used.

causing it to congeal before it was actually poured into the plate and mixed with the inoculum.

Duplicate tubes of each of the media under experiment were melted and kept in a 50° C. water bath. The petri dishes required (two for each media tested) were readied by pipetting into each the required amount of the appropriate dilution of the inoculum and each properly labeled. The tubes of media were taken from the water bath one at a time and cooled to body temperature by twirling continually in a breaker of cold water. The tube was further twirled a few seconds in air and the medium poured into the corresponding petri-dish. Then the inoculum and the medium were mixed thoroughly. By actual check, the temperature of the medium at the time of pouring ranged between 32° C. to 35° C.

Incubation temperature.—All culture plates were incubated at room temperature ranging from 23.5° C. to 27° C. taken at about 8:00 A. M. and 27° C. to 30° C. taken at about 3:00 P. M. during the period of these experiments.

Incubation period.—On the basis of observations made on preliminary trials, an incubation period of 96 hours for all inoculated plates was allowed before their corresponding colony counts were taken. This short period of incubation was adopted to minimize difficulties in taking accurate counts occasioned by the presence of spreaders which were frequently encountered in a good number of the media tried. Molds which become more troublesome after 96 hours and the rapid growth of some colonies in certain media which after 96 hours when close to one another usually coalesced and contributed their share of difficulty were avoided by this short period of incubation.

Observations made in this connection showed significant increases in the number of colonies up to about a week and that the plate indicating the highest count after 96 hours incubation generally gave the highest count after 7 days incubation.

Method of enumeration.—A direct total count of all the colonies in a plate was made whenever possible. When the colonies were close (over 300 to 400), the Quebec colony counter was used. After computing for the count per cubic centimeter (or per gram) of the undiluted specimen, the counts in the two dilutions in which the specimens were invariably plated, were averaged to obtain the final count per cubic centimeter (or per gram) of the specimen in each of the media tested.

To complement the data obtained in the series of trials performed under the subject of this investigation as indicated in the caption under which this report is being presented, the effects of the following factors on the bacterial colony counts were investigated.

1. *Diluents.*—Distilled water and physiological saline (0.85 per cent NaCl) were tried. "Aged" sea water was used as control diluent.

2. *Plating temperature of medium.*—Plating temperatures of 55° C., 50° C., and 45° C. were tried. The technique described above to attain a temperature of 32° C. to 35° C. in the plating medium at the time of pouring was used with the control plates.

Incubation temperature.—Incubation temperatures of 37° C. and 45° C. were tried. The controls were incubated at room temperature (vide supra).

In all these complementary experiments, the same procedure as discussed previously was employed, except where the particular variation under consideration was concerned. Medium 2216 was used in these trials.

RESULTS AND DISCUSSION

The eight formulas investigated had to be compared in groups of three or four owing to lack of adequate facilities. Five series of trials were run comparing a given group of formulas in each. Formula 1 was included in all the trials to afford a basis of comparison for all the formulas tested. The counts obtained in the individual trials are given in Table 1 and are expressed in per cent. A value of 100 per cent has been assigned to the count in Formula 1 and the proportionate percentage computed for the counts obtained in the other formulas in a given trial.

The results of the first trial illustrate the superiority of media with sea water as menstruum over those with distilled water as menstruum. Formulas 2, 3, and 4 are identical (vide supra) except for the menstruum employed and amount of sodium chloride in each. This observation conforms with those of ZoBell (1941, 1946), ZoBell and Feltham (1934), and others. Besides supporting the growth of very much fewer organisms, spreaders were particularly troublesome in Formula 3, both plates being completely overgrown with them making an accurate count impossible.

TABLE I.—*Bacterial counts in the various media tested.*

Media	Series I		Series II			
	1	2	3	4	5	6
Formula 1	0.100	100	100	100	100	100
Formula 2	3.22	96.58	64.54	62.5	267.62	69.76
Formula 3	(b)					
Formula 4	0.25					
Formula 5			54.32	84.61	247.12	50.95
Formula 6						
Formula 7						
Formula 8						

Media	Series III							
	7	8	9	10	11	12	13	14
Formula 1	100	100	100	100	100	100	100	100
Formula 2	78.39	22.85	80.00	50.00	26.07	58.73	23.68	81.37
Formula 3								
Formula 4								
Formula 5	59.79	21.42	153.00	50.00	34.95	19.04	24.56	18.06
Formula 6	45.22	22.85	40.00	8.33	37.82	25.39	27.19	46.06
Formula 7								
Formula 8								

Media	15	16	17	18	19	20	21	22
Formula 1	100	100	100	100	100	100	100	100
Formula 2	35.71	24.65	134.50	2.73	33.33	400.00	76.92	12.69
Formula 3								
Formula 4								
Formula 5	75.89	76.13	66.07	15.06	70.00	223.25	215.38	79.36
Formula 6	14.28	5.68	71.42	9.58	11.66	255.34	230.76	95.23
Formula 7								
Formula 8								

Media	23	24	25	26	27	28	29	30
Formula 1	100	100	100	100	100	100	100	100
Formula 2	61.19	8.39	28.57	45.55	24.00	39.58	374.61	21.31
Formula 3								
Formula 4								
Formula 5	27.79	10.58	33.03	11.48	32.00	45.88	51.02	63.93
Formula 6	27.79	3.05	6.25	32.76	22.00	18.75	83.46	36.88
Formula 7								
Formula 8								

Media	Series IV							
	31	32	33	34	35	36	37	38
Formula 1	100	100	100	100	100	100	100	100
Formula 2	140.38	40.34	36.36	11.71	65.56	1.19	13.82	76.32
Formula 3								
Formula 4								
Formula 5	76.92	48.92	14.54	1.17	50.40			
Formula 6	53.84	49.35	52.72	4.31	56.09			
Formula 7						1.40	1.34	31.63
Formula 8								

[a] All counts are expressed in per cent. See text for method of computation.
[b] Count not determined due to spreaders.

TABLE I.—*Bacterial counts in the various media tested.*—Continued

Media	39	40	41	42	43	44	45	46
Formula 1	100	100	100	100	100	100	100	100
Formula 2	34.11	16.00	56.86	135.03	106.87	34.61	16.26	17.7
Formula 3								
Formula 4								
Formula 5								
Formula 6								
Formula 7	9.41	4.00	20.91	10.82	0	18.13	2.36	4.81
Formula 8								

Media		Series V								
	47	48	49	50	51	52	53	54	55	56
Formula 1	100	100	100	100	100	100	100	100	100	100
Formula 2	100	53.73	76.47	87.87	92.30	79.03	90.38	67.74	34.09	71.69
Formula 3										
Formula 4										
Formula 5										
Formula 6										
Formula 7	36.36									
Formula 8		83.58	47.05	98.48	96.15	46.77	67.30	156.45	101.13	56.60

The comparative values in per cent of the different media used in each of the series are given in Table 2. The values values given under individual series are averages of the percentage of values obtained for the various media in the trials run in that particular series. The figures in the column marked "final values" represent the final averages of the various serial averages obtained for a given medium where the latter was compared in two or more series (Formulas 1, 2, and 5), and where the medium was employed in only one series, the average obtained for the medium in that series (Formulas 4, 6, 7, and 8). Of the eight formulas investigated, Formula 1 apparently satisfies the cultural requirements of the greatest number of bacteria in the materials plated. Formula eight with an average bacterial count of 83.72 per cent is second in this respect. Then we have Formulas 5, 2, 6, 7, and 4 decreasing in average in that order.

While information on the comparative ability of the various media investigated to satisfy the cultural requirements of the

TABLE 2.—*Comparative values in per cent of the different media tested*

Media	Series					Final values
	1	2	3	4	5	
Formula 1	100	100	100	100	100	100
Formula 2	49.90	116.10	70.31	50.77	72.58	71.93
Formula 3	(a)					(a)
Formula 4	0.25					.25
Formula 5		109.25	57.57			83.41
Formula 6			48.07			48.07
Formula 7				12.85		12.85
Formula 8					83.72	83.72

[a] Not determined.

bacteria in the materials plated was the principal objective of this duty, observations on the following factors which may affect the number of colonies and/or facilitate their enumeration were made:

1. Uniformity in composition of batches of a given medium prepared from time to time.
2. Absence of obstructing precipitates in the medium after sterilization.
3. The growth of well defined, discrete colonies which do not tend to grow rapidly and coalesce,
4. Minimum growth of spreaders, bacterials or otherwise.

The ingredients which go into the preparation of Formulas 1, 2, 3, 4 and 8, with the exception of sea water whose composition is relatively constant (ZoBell, 1946), are standardized, and therefore, variations in the composition in batches of these media prepared at different times are negligible. Formulas 5, 6, and 7, however, call for infusions of "alamang", fish and oysters, respectively, whose inherent composition varies according to the source of the raw material and season of the year (Beck 1941) to mention only two factors which may influence the composition of the prepared medium. When properly prepared, Formulas 1, 2, 3, 4, and 8 were clear while varying amounts of precipitates were usually present in Formulas 5, 6, and 7 even after repeated filtrations before sterilization. Colonies growing in plates where any of the first group of media was used, were generally discrete and slow growers. This made possible easier and more accurate enumeration of the same than in plates where any of the second group of media, in which varying number of larger and faster growing colonies were observed, was used. No attempt, however, was made to determine whether the bacteria observed growing in the first group of media were of the same types as those growing in the second group.

On the basis of these observations, Formulas 1, 2, and 8 rank about the same and are superior to the rest of the formulas tried. The choice among these three media is therefore based on their comparative individual ability to meet the cultural requirements of the greatest number of bacteria in the materials plated (Table 2).

The results of the complementary experiments to determine the effect of various diluents, and varying plating and incubation temperatures on the total number of bacterial colonies are

given in Table 3. In general, they conform to the pertinent observations made by ZoBell (1941, 1942, 1946), ZoBell and Conn (1940), and ZoBell and Feltham (1935 and 1938).

Distilled water and physiological saline have a definite detrimental effect on the bacterial population when used for the preparation of the tenfold dilutions of the inoculum. Counts 41.89 per cent to 100 per cent lower were obtained when distilled water and physiological saline dilution blanks were used, or an average of 81.81 per cent and 60.97 per cent lower, respectively, than when "aged" sea water was used.

Plating temperatures of 55°C., 50°C., and 45°C. compared with the control plating temperature of 32° C., to 35° C. have definite, though less marked adverse, effects on the counts than distilled water and physiological saline diluents have compared with the corresponding controls. Counts 12.82 per cent to 64.70 per cent lower were obtained when plating temperatures of 55°C., 50°C., and 45°C. were employed, or an average of 30.87 per cent, 36.40 per cent, and 39.04 per cent lower, respectively, than that of the controls. The comparative closeness of the temperatures tried and the difficulty of insuring a uniformity of the factors affecting the rate of cooling of the medium after it is poured, however, has resulted in counts which while consistently lower than those obtained in the corresponding controls, show no definite trend in relation to the plating temperatures. These factors include, among others, the amounts of plating medium actually poured into the plate, the precise moment of contact between the inoculum and the plating medium and the rate and duration of rotation of the petri dish.

TABLE 3.—*Effect of various diluents, varying plating temperatures of medium and varying incubation temperatures on the total bacterial plate counts using 2216 medium.*

Trial	Control[a]	Diluent		Plating temperature			Incubation temperature	
		D.W.*	S.S.*	55° C	50° C	45° C	37° C	45° C
1	7,750[b]	500	1,000	4,250	6,750	4,500	2,750	1,500
2	8,500	0	3,500	6,500	3,000	4,750	5,750	500
3	12,500	2,500	5,500	7,250	6,000	8,250	6,750	3,000
4	85,750	12,250	49,750	74,750	72,000	54,750	79,250	43,250

* D. W. = Distilled water. S. S. = Physiological saline (0.85 per cent NaCl).

[a] The controls were prepared according to technique described under "Methods" using "aged" sea water diluent, a plating temperature of 32°–35°C. and room temperature incubation.

[b] Figures represent total bacterial count per 1 cc of the undiluted material.

Plates incubated at 37° C., and 45° C. show definitely lower counts than the controls which were incubated at room temperature. Counts 7.58 per cent to 80.64 per cent lower were obtained in plates incubated at 37° C. and 45° C., or an average of 37.61 per cent and 75.07 per cent lower, respectively, than those of the controls incubated at room temperature.

CONCLUSIONS

From the results obtained and under the conditions and limitations set forth in this paper, the following conclusions are drawn:

Formula 1, 2216 medium of ZoBell, satisfies the cultural requirements of the greatest number of bacteria in the materials of marine origin examined as evidenced by the counts obtained. This is, therefore, the most suitable among the 8 plating media tried for determining the total aerobic bacterial population in materials of marine origin.

Formula 8, a modification of the media recommended by the Woods Hole Oceanographic Institution in which KH_2PO_4 has been substituted for K_2HPO_4 which the original formula requires gave the second highest count. It is recommended as second choice.

While the counts in Formula 2 gave a lower average than those in Formula 5, the former is preferred to the latter due to the possibility of greater variations in composition and the presence of precipitates and frequency of spreaders in the latter. Formula 2, therefore, is recommended as third choice.

"Aged" sea water for preparing dilutions of the inoculum is definitely superior to either distilled water or physiological saline (0.85 per cent sodium chloride in distilled water) when the objective is for maximum plate counts.

A plating temperature of 32°–35° C. of the medium, attainable by a technique described, results in definitely higher counts than those obtained with plating temperatures of 55° C., 50° C., and 45° C.

Plates incubated at room temperature gave definitely higher counts than duplicate plates incubated at 37° C. or 45° C.

Significant increases in colony counts have been observed up to about 7 days' incubation at room temperature. Molds and spreaders, however, become correspondingly more troublesome with the increase in incubation period. Hence, where a com-

parative periodic check on the total bacterial count of a given material is the objective, the shorter incubation periods are to be preferred.

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